Geology and Minerals
OF
Quebec

By

W. L. GOODWIN, D.Sc., LL.D.


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GEM·CUTTING
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A HANDBOOK

for

MINE PROSPECTING

in

QUEBEC

Geology and Minerals

of

QUEBEC

PREPARED FOR THE INSTRUCTION AND GUIDANCE OF
THOSE PROSPECTING IN QUEBEC

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PREFACE

In preparing this book, the reports of the Geological Survey of Canada and the Mines Branch have been freely drawn upon. Much information has been taken from the reports and bulletins of the Quebec Bureau of Mines. The author's obligations to these sources, and to others mentioned in references, are hereby acknowledged. The rate of discovery and development of mineral deposits in Quebec is so rapid that it is impossible to be up to date in a publication of this kind, but the latest information available at the time of writing has been used.

Experience has shown that a very wide range of valuable minerals may be found in the Precambrian formations of Canada. For this reason, minerals have been described that have not yet been found in the province, or that have been observed only in small quantities of no economic importance. The wider the knowledge of such minerals, the more likely are they to be noticed by prospectors and others.

Gardenvale, P.Q.,
Oct. 30th, 1929.

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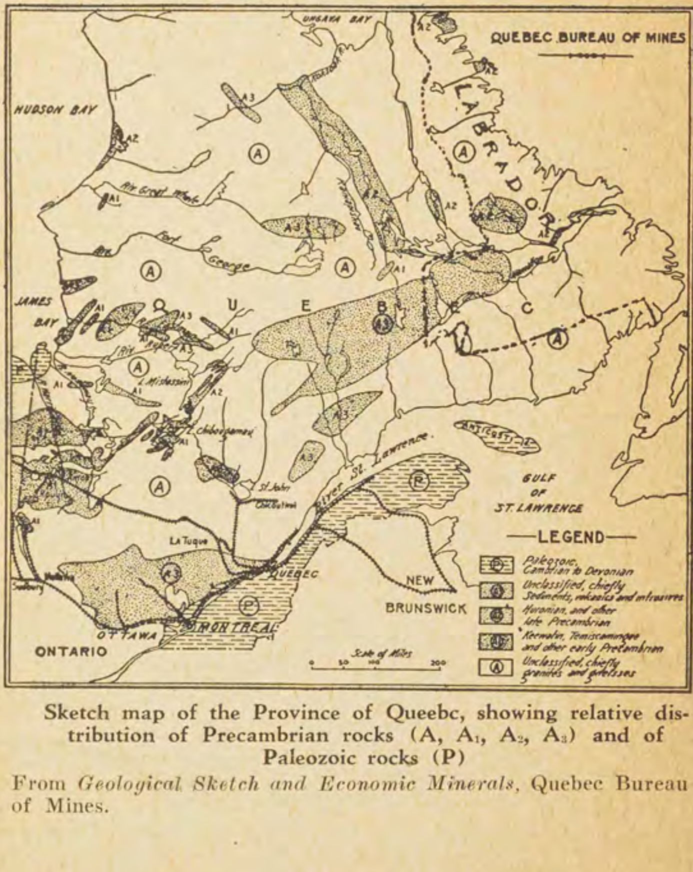


Sketch map of the Province of Queebc, showing relative distribution of Precambrian rocks (A, A_1, A_2, A_3) and of Paleozoic rocks (P)

From *Geological Sketch and Economic Minerals*, Quebec Bureau of Mines.

Geology and Minerals of Quebec

CHAPTER I

MINERALS, ROCKS, ORES, MINERAL DEPOSITS

INTRODUCTION

In the reports of the Quebec Department of Mines and of the Geological Survey of Canada, there is a large amount of information about geology and mineral deposits. In addition to these sources, special reports have been published by the Mines Branch, Ottawa, on certain kinds of mineral deposits such as mica, feldspar, barite, iron ores, etc. This book is an attempt to assemble all such information insofar as it may have a bearing upon mineral development, and to state it in such terms that it will be readily available for prospectors and others interested in the search for and development of mineral deposits in this province. To make the special information more easily intelligible to readers who have no technical education, a few pages are given to short descriptions of minerals, rocks, geological formations, and mineral deposits.

MINERALS

Any distinct substance found in the earth's crust is called a mineral, whether it has any value or not. Valuable mineral deposits may be composed altogether of one or several valuable minerals, such as a body of pure hematite, or of valuable minerals mixed with others of no value, as gold mixed with quartz, or galena mixed with calcite. Rocks are composed of minerals, mostly of no particular value, called rock-forming minerals.

ROCK-FORMING MINERALS

It will be convenient to describe here a number of minerals that enter into the composition of rocks. Most of them are alike in composition in that they are partly composed of **silica**, the substance of which quartz is completely composed.

Silicates.—Minerals composed partly of silica are called silicates. The rock-forming silicates mostly belong to four families, the **feldspars**, the **mica family**, the **hornblende** or **amphibole family**, and the **pyroxene family**. The **feldspars** are light-colored minerals and also light in weight. They are silicates of alumina, with one or more of potash, soda, and lime. They are often distinguished as potash feldspar, soda feldspar, lime feldspar, soda-lime feldspar, etc., according to their composition. Potash feldspars and soda feldspars are high in silica. Lime feldspars are low in silica. Such well-known rocks as granite and syenite are made up largely of grains of feldspar, mostly of the potash and soda kind. Other rocks such as dia

base, diorite, and gabbro contain feldspars more sparingly, and the feldspars are largely of the lime variety. The **micas** that enter mostly into the formation of rocks are **biotite** or **black mica,** seen as black specks in ordinary granite, and **white mica** or **muscovite,** which is plentiful in some varieties of granite. A third member of the family, **phlogopite** or **amber mica**, is found mostly in crystalline limestone. **Sericite** is a variety of white mica. The **hornblende** family includes minerals that are heavier than the feldspars and mostly black or dark in color. They are silicates of magnesia, etc., with generally a considerable proportion of iron, which accounts for their weight and dark color. Hornblende is the principal constituent of the rock, diorite, and often occurs as part of granite and syenite. The **pyroxene** family resembles the hornblende family in composition and appearance. The rocks diabase and gabbro are made up largely of varieties of pyroxene, which accounts for the usual dark color and the weight of these rocks.

In addition to these families of rock-forming silicates, there are other silicates less common but found plentifully enough to merit mention. **Garnets** are often seen as constituents of rocks that have undergone radical changes after being formed (metamorphic rocks). There are several rocks (dunite, peridotite, etc.,) composed more or less of the green mineral **olivine,** a silicate of magnesia and iron. **Epidote** is a greenish-yellow silicate of alumina, iron, lime, etc. It is apt to be seen near places where igneous rocks have altered the rocks through which they have broken. Its bright color often makes it conspicuous at these **con-**

tacts. **Chlorite**, is a soft silicate, usually of a greenish color, and in thin scales like mica. It is found in metamorphic rocks, such as chlorite schist, and it is also common in mineral deposits. **Talc** is a silicate of magnesia with water. It is soft and feels soapy when rubbed. Impure talc is often called soapstone, which sometimes forms extensive masses of rock. Talc forms the greater part of the rock talc schist. **Serpentine** is also a silicate of magnesia with water. It is a good deal like talc but harder. It often has a waxy look. Chlorite, talc, and serpentine are **secondary minerals.** They have been made out of other minerals such as pyroxene, hornblende, and olivine, that were there in the first place.

Kaolin.—When feldspars decay under the influence of water, they lose potash, etc., and gain water. The secondary mineral thus formed is called kaolin, or kaolinite. It is silicate of alumina with water. The surfaces of certain rocks are often seen to be covered with a soft layer of this substance, because the feldspar has been kaolinised.

Quartz.—This is a very common mineral forming a considerable part of granite, one of the commonest rocks, and also the main part of common sand and of sandstone. It also forms part of many deposits of valuable minerals. There are a great many varieties of quartz, but in granite it is usually white, light gray, or very pale blue. It is hard enough to scratch steel.

Calcite.—This is the mineral forming the greater part of limestone. It is carbonate of lime, and when strongly heated, as in lime kilns, it loses carbon dioxide, and lime remains. In the ordinary sedimentary

limestone, the characteristics of crystallized calcite are not apparent, but in crystalline limestone, the grains of calcite with their perfect cleavage are easily seen. Calcite often forms part of deposits of valuable minerals, as in some zinc and lead ores. **Dolomite** is carbonate of lime and magnesia. Limestone is often of this composition, and it is then called hard limestone, because dolomite is harder than calcite.

ORES OF METALS

Gold.—The metal itself (native gold) is the form in which the greater part of the gold is found, but there are several minerals called **tellurides** that are compounds of gold and tellurium. Part of the production of gold is as a by--product from copper, zinc, lead, and nickel ores. A good deal of gold is produced from **placer** diggings, where the native gold in the form of nuggets and small flattened grains or scales (gold dust) is found mixed with sand and gravel. Gold placers are formed by the slow decay or breaking up of gold veins, the loosened materials being washed downhill till the heaviest materials come to rest in a hollow. The gold on account of its weight is thus concentrated under the gravel and sand.

Silver.—Native silver has been found in the ore of the Tetreault and Calumet Island mines. **Argentite** is composed of silver and sulphur. It is a black mineral, very heavy and soft. It can be cut like lead. **Proustite** or **light red silver ore** is composed of silver, arsenic, and sulphur. It is of a bright red color.

Pyrargyrite, or **dark red silver** ore, is **dark** red or nearly black. It is composed of silver, antimony and sulphur. **Dyscrasite** is a heavy gray mineral composed of silver and antimony. **Cerargyrite,** or **horn silver,** is a pearl gray mineral that tarnishes to a purple brown color. It is soft and cuts like horn. A good deal of silver is obtained as a by-product in the smelting and refining of ores of lead, zinc, and copper.

Copper.—The metal itself is found in nature (native copper), and important amounts have been produced as native copper. The commonest ore is **chalcopyrite,** or **copper pyrites,** composed of copper, iron, and sulphur, about one third of each. It sometimes carries gold and silver. It is a golden yellow mineral softer than steel. It grinds to a nearly black powder. When the mineral weathers, the presence of iron is shown by the rust that is left. **Chalcocite** is a soft gray mineral composed of copper and sulphur. It contains nearly 80% of copper. It sometimes carries gold and silver. **Tetrahedrite,** or **gray copper ore,** is similar to chalcocite in appearance. It is composed of copper, antimony, and sulphur. It sometimes carries silver or mercury. **Bornite,** or **peacock copper ore,** is composed of copper, iron, and sulphur. The copper varies from 44% to 71%. Bornite is of a coppery brown color, but the surface is usually tarnished to a variety of brilliant colors, green, blue, red, etc. Where copper minerals have weathered, there is often a green stain (**malachite**) or a blue stain (**azurite**). These are carbonates of copper. They are sometimes formed in considerable quantities.

Nickel.—The principal ore of nickel is **pyrrhotite,**

a heavy, bronze-yellow mineral, composed essentially of iron and sulphur, but sometimes with enough nickel to make it a nickel ore. Oftener than not it has no appreciable quantity of nickel. In the Sudbury region, Ontario, the pyrrhotite is mixed with small quantities of **pentlandite** (a sulphide of nickel and iron) and **polydymite** (a sulphide of nickel). A sulphide is a mineral composed of sulphur and a metal. **Millerite** is a sulphide of nickel. It is nearly the same color as copper pyrites. **Niccolite** is a hard, heavy, copper-colored mineral composed of nickel and arsenic. It is often found in the silver veins of the Cobalt area, Ontario.

Cobalt.—A good deal of this metal and its oxide are produced as by-products of the silver mines of Ontario. The principal ore of cobalt is **smaltite,** a heavy, hard, gray mineral composed of cobalt and arsenic. There are several other cobalt minerals found in the silver veins. On weathering they form **erythrite,** a pink mineral, the "cobalt bloom" of the prospector.

Zinc.—**Zinc blende** or **sphalerite,** is the principal ore of zinc. It is sulphide of zinc, and the pure mineral contains about 67% of zinc. The ore is commonly black, and miners often call it **black jack.** It turns brown when powdered. The purest varieties look much like rosin. Zinc blende sometimes carries important quantities of silver and gold. This is more apt to occur with the black jack than with the light-colored varieties.

Lead.—Galena is the common ore of lead. It is a heavy, soft, lead-gray mineral, composed of lead and sulphur. By weathering it forms **cerussite** (carbonate

of lead), and **anglesite** (sulphate of lead), heavy, soft, white minerals. Galena often carries important quantities of silver.

Arsenic.—The white powder known commonly as arsenic is composed of oxygen and a gray metallic-looking substance, properly called arsenic. Both arsenic and its oxide, white arsenic, are articles of commerce. The chief ore is **mispickel** or **arsenopyrite**, composed of iron, sulphur, and arsenic. It is a hard, heavy, gray mineral much resembling smaltite. Arsenic minerals are often classed as **arsenides.** Many of the minerals of the Cobalt silver ores belong to this class. In the smelting of these ores, arsenic is produced as a by-product.

Antimony.—The chief ore of antimony is **stibnite,** a heavy, soft, gray mineral, composed of antimony and sulphur. It contains nearly 72% of antimony. It sometimes carries important quantities of gold. **Native antimony** is a heavy substance of a tin-white color, and not very hard.

Tin.—**Cassiterite** or **tinstone** is the chief ore of tin. It is a very heavy, hard mineral, usually black, but sometimes brown or dull gray. It is composed of tin and oxygen. Most of the world's supply of tin ore is from placer diggings.

Iron—Hematite is the most important ore of iron. It varies a great deal in appearance. The pure crystallized mineral is heavy, hard, and from gray to nearly black in color. When powdered finely, it turns red. Some bodies of hematite are soft and red, because they are really a compacted powder. The pure mineral contains 70% iron, the rest being oxygen. **Magnetite**

is another oxide of iron. It is notable among minerals for its magnetic property. It is hard, heavy, black, and forms a black powder. The pure mineral has 72.4% iron. **Limonite** is a heavy brown mineral, sometimes soft and looking like iron rust, sometimes hard and darker brown. It is composed of iron, oxygen, and water. The pure mineral contains nearly 60% iron. **Siderite** is carbonate of iron containing about 48% iron. It is light gray to brownish in color. It often looks a good deal like calcite, but is harder and heavier.

Aluminum.—The only ore of aluminum at present in use is **bauxite,** composed of aluminum, oxygen and water. It is somewhat like clay in appearance. It is found mostly in superficial deposits.

Manganese.—**Pyrolusite** is the common ore of manganese. It is a soft, black mineral, composed of manganese and oxygen. **Psilomelane,** or **hard manganese ore** is not so common. Manganese is important in steel manufacture.

Chromium.—**Chromite,** the only ore of chromium, is a hard, heavy, black mineral, somewhat like magnetite, but powdered chromite is brown, while magnetite gives a black powder. Chromite is composed of iron, chromium, and oxygen. Chromium is used in the manufacture of chromium steel and stellite. A number of paints and chemicals are manufactured from chromite.

Titanium.—The chief ores of titanium are **rutile** and **ilmenite.** Titanium has not come into use as a metal, but an alloy, **ferro-titanium,** has been extensively used as a purifier of steel. There are a number of titanium

compounds of growing importance commercially. **Rutile** is titanium oxide. It is a hard, red, or reddish brown, rather heavy, mineral. **Ilmenite** is black and much like magnetite in appearance, but it is not so strongly attracted by a magnet.

Tungsten.—Wolframite is composed of iron, manganese, tungsten, and oxygen. It is black or brownish black and turns red-brown when powdered. It is hard and heavy. **Scheelite** is usually white, yellowish, or pale brown. It is not so heavy or so hard as wolframite. In composition it is tungstate of lime. A third mineral, **tungstite**, is formed by the weathering of wolframite and scheelite. It is of a golden or canary yellow color. There is demand for tungsten ores to make tungsten steel, filaments for electric lights and several other products.

Molybdenum.—The chief ore is **molybdenite**, composed of molybdenum and sulphur. It is a soft mineral much like graphite, from which it can be distinguished by its weight and by the greenish tint of a mark made on white paper and rubbed until it is spread out very thin. The ore is in demand for making molybdenum steel and other alloys.

Uranium and Radium.—The commonest ore of these two metals is **pitchblende**, a very heavy, hard mineral, pitch-black, greenish black or brown black, turning greenish or brown when finely powdered.

Vanadium.—The ores of vanadium are **patronite**, composed of vanadium and sulphur, **carnotite**, which is also an ore of uranium and radium, and **roscoelite**, or **vanadium mica**. Patronite is found in mineral pitch in Peru. The ash of coal and bitumen is sometimes

rich in vanadium. Carnotite is a canary yellow mineral sometimes found as a crust on ilmenite. Ilmenite generally contains a small percentage of vanadium. Vanadium ores are in demand for the manufacture of vanadium steel.

OTHER VALUABLE MINERALS

Pyrite.—Often called **iron pyrites.** It is a heavy, hard, golden yellow mineral composed of iron and sulphur. It is valuable because of the sulphur of which the pure mineral contains over 53%. It easily strikes fire with steel.

Graphite.—This is a form of carbon. It can be made artificially from coke. The natural substance is soft, light, dark gray to nearly black and marks paper. The lead of lead pencils is graphite.

Apatite.—Commonly called **phosphate.** It is phosphate of lime, etc. It is a fairly hard, medium heavy mineral, brown, green or bluish. It is used for making phosphorus and superphosphate.

Mica.—Two varieties of mica are used, **white mica** or **muscovite,** and **amber mica** or **phlogopite.** To be merchantable, mica must be capable of splitting into thin sheets without cracks, crinkles, or spots of hematite or other minerals that may destroy the insulating power for electricity.

Feldspar.—Most commercial feldspar is the variety called microcline, but **orthoclase** and **albite** are used to some extent. Commercial feldspar is found in a variety of granite, called pegmatite.

Fluorspar.—Also called **fluorite**. It is of medium hardness and weight, and somewhat resembles calcite, but is harder. It is often white, but sometimes green, blue or purple. It is used mostly as a flux in steel making, but also as an ingredient of enamels.

Barite.—Sometimes called **barytes.** It is a heavy, soft mineral, and usually white. It is composed of barium, sulphur, and oxygen. Its chemical name is **barium sulphate**. It is used mostly to make white paint.

Celestite.—Somewhat like barite, but commonly has a somewhat fibrous structure. Its chemical name is **strontium sulphate.** It is used as the raw material for making a number of strontium compounds, including strontium nitrate for red fire.

Magnesite.—This is much like calcite, but is harder and a little heavier. Its composition is similar to that of calcite, but with magnesia instead of lime. It is used to make magnesia for the manufacture of magnesia bricks. It is also the starting point in the manufacture of the metal magnesium.

Asbestos.—This is mostly a fibrous kind of serpentine, although fibrous hornblende was the original asbestos. Quebec produces large quantities of asbestos. Ontario has produced a little.

Talc.—This has already been described as a rock-forming mineral.

Cryolite.—This is a mineral of rather unusual composition. Its chemical name is fluoride of sodium and aluminum. It is a soft mineral, not quite so hard as calcite, but a little heavier. It looks rather like quartz but is much softer. Its color is usually white, and it

looks much like ice, particularly when it is wet. Sometimes it is reddish, brownish, or even black. It is found in veins in rocks of the granite species. The only workable deposit so far found is in Greenland. It is used as a flux in the manufacture of aluminum and also as an ingredient of **enamels.**

Corundum.—This is a very hard, rather heavy mineral, mostly gray, but sometimes blue or red. Emery is impure corundum, and the two are used for the same purposes, as abrasives.

Gypsum.—This soft, white mineral is found in layers among rocks of the sedimentary class. Its chemical name is hydrated sulphate of calcium. Calcium is a metal that with oxygen forms lime. So gypsum is some times called sulphate of lime. When carefully heated it loses water and becomes plaster of Paris, a material of growing importance in the construction of buildings.

Salt.—The chemical name of salt is sodium chloride. **Rock salt** is the name used to distinguish the solid mineral as it is found in layers among sedimentary rocks. It is often found along with gypsum. Both have come from the evaporation of sea water.

ROCKS AND ROCK STRUCTURES

A rock is any important essential part of the earth's crust, as distinguished from veins and other structures that may be looked upon as occasional and subordinate masses in the rocks. But, as is usual with definitions, no sharp line can be drawn between rocks

and these other structures. Rocks are composed of minerals, usually of several, but sometimes of one.

There are three classes of rocks:—

1. Igneous.
2. Sedimentary.
3. Metamorphic.

Igneous rocks are formed by the cooling of hot liquid rock material which is called lava when it comes to the surface, as it does from volcanoes. By the quick cooling of this material very fine-grained or even glassy rocks are formed. This kind of igneous rocks receives the name **volcanic**. Masses of the same materials have in past ages cooled slowly at great depths beneath the surface so as to allow the formation of a coarse-grained structure, such as can be seen in granite. Some of these masses have been exposed by the erosion of the rocks that originally covered them. These igneous rocks formed at great depths are called **plutonic**. Intermediate between volcanic and plutonic rocks are the **porphyries**, in which there was a period of slow cooling with the formation of large grains (crystals), followed by rapid cooling such that the remaining liquid formed a very fine-grained or glassy mass enclosing the larger crystals. Among the igneous rocks there are large differences in the proportion of silica, the substance that forms quartz and in part the silicates. Rocks that have more than 50% of silica are usually called **acid rocks**, while those that have less than 50% are called **basic rocks**. Volcanic rocks are found as lava **flows**, covering other rocks, or as **dikes**, etc., that have formed by the cooling of lava in cracks and other openings near the surface. Plutonic rocks

Acid rocks >50% Si

are often in great masses, sometimes hundreds of miles in extent, and believed to go to great depths **(batholiths)**. They are also seen in dikes and other comparatively small masses. **Sills** are sheets of plutonic rocks lying among the other rocks in a nearly horizontal position. If they were more nearly upright they would be called dikes. **Laccoliths** are masses that have formed where the molten rock has made a large space for itself by pushing upwards and sideways among the other rocks. Dikes, sills, laccoliths, and batholiths are called **intrusions** or **intrusive igneous rocks**, when it can be seen that they have broken into or through the other rocks there before their advent. The majority of mineral deposits are connected with igneous intrusions.

The following tabular statement includes the commoner volcanic and plutonic rocks corresponding to them:—

Rhyolite same chem compos as granite, but fine grained

	ACID	
Volcanic		**Plutonic**
Rhyolite		Granite
Trachyte		Syenite
	BASIC	
Basalt		Gabbro, Diabase
Andesite		Diorite

Rhyolite is of the same composition as granite, but is too fine grained to show the grains or crystals of quartz, feldspar, and mica visible in granite. Similarly for the other pairs, trachyte and syenite, etc.

Granite is composed of quartz, feldspar and usually mica or hornblende or both of these minerals. **Syenite**

is like granite but it has little or no quartz. **Gabbro** and **diabase** are composed of pyroxene and feldspar. They differ in microscopic structure. **Diorite** is composed of hornblende and feldspar.

Acid rocks such as granite are mostly light-colored and light in weight. Basic rocks, like gabbro and diabase, are mostly dark colored and heavy.

Sedimentary rocks are formed largely of fragments of other and older rocks, but also more or less of materials that have been precipitated from bodies of water and deposited as sediments. To understand sedimentary rocks it is necessary only to think of all the present deposits of loose material, such as sand, gravel, and various kinds of mud and clay lying at the bottom of bodies of water, or spread out on the dry land. The same kinds of collections, consolidated by pressure and cementing material, form the common sedimentary rocks such as sandstone, conglomerate, shale, and limestone. **Sandstone** has been made by the consolidation of beds of sand, **conglomerate** from gravel, **shale** from clay, and **limestone** in part from shells of minute and larger animals and plants, and in part from carbonate of lime precipitated from the water. As the shells are also made mostly of carbonate of lime, the rock as a whole is of that composition. The bodies of plants and animals covered up in the mud and sand of past ages have become **fossils**. It is partly by means of the fossils that geologists are able to determine the relative ages of sedimentary rocks. Where the rocks have not been changed since consolidation by folding or overturning, it is obvious that any layer is younger than the layers beneath it. By study of the fossils in unchanged sedi-

mentary rocks all over the world, a certain succession in the living beings characteristic of each age has been made out. These results are shown in the following table, in which the names of eras and periods are also the names of the rock groups and systems. At the beginning are the unconsolidated materials covering the rocks, mostly the result of glacial action. The loose materials formed since the Great Ice Age are called **Recent**. Next older come the **Glacial** deposits, and so on.

Era or Group		**Period or System**
Cenozoic	Quaternary or Age of Man.	Recent Glacial (Pleistocene)
	Tertiary or Age of Mammals	Pliocene Miocene Eocene
Mesozoic or Secondary	Age of Reptiles	Cretaceous Jurassic Triass.c
Paleozoic or Primary	Age of Amphibians Age of Fishes	Permian Carboniferous Devonian
	Age of Invertebrates	Silurian Ordovician Cambrian
Eozoic or pre-Cambrian	Dawn of Life	Keweenawan Animikean Algoman Timiskamian Laurentian Grenville Keewatin

Metamorphic Rocks.—These are rocks formed by the alteration of rocks of the other two classes by heat, pressure, and the action of hot liquids and gases coming from lava or hot igneous rocks. The changes may be more or less complete according to circumstances. Thus shale becomes slate, and by further alteration it is changed to mica schist. The effect of pressure is to develop a layered structure, and when this has gone far enough the layers are very thin, forming a **schist**. There are many kinds of schists. Any rock of the igneous or sedimentary classes may be converted into a schist. In the following table some of the commoner igneous and sedimentary rocks are shown with their metamorphic equivalents:—

Sedimentary	**Metamorphic**
Conglomerate	Gneiss and Schist
Sandstone	Quartzite and Schist
Shale	Slate and Schist
Limestone	Crystalline Limestone
Igneous	**Metamorphic**
Granite	Gneiss
Syenite	Gneiss
Diorite	Gneiss
Rhyolite, etc.	Schists
Peridotite	Serpentine

MINERAL DEPOSITS

By this is meant those concentrations of minerals that have possible commercial value. A great many of these deposits are in the form of veins and other struc-

tures that have originated in connection with intrusions of **igneous** rocks. Others are sedimentary in origin, and may be found among the layers of sedimentary rocks. Still others have probably been concentrated in cavities in the rocks by the action of circulating water from above. The most important mineral deposits from the point of view of variety and value are those that owe their origin to igneous intrusive rocks. For example, something like **80% of the productive** gold mines of the world are closely connected with intrusions of porphyry. Canada is fortunate in having in most of the provinces large areas where igneous intrusions are plentiful.

CHAPTER II

SKETCH OF THE GEOLOGY OF QUEBEC

Quebec may be divided into three regions:

(1) The St. Lawrence

(2) The Appalachian

(3) The Precambrian

THE ST. LAWRENCE REGION..

The **St. Lawrence Region** extends from the Ontario boundary on the west along the St. Lawrence valley to Quebec city. The flat-lying Paleozoic beds that characterize it occur at intervals beyond Quebec along the north side of the St. Lawrence. The Mingan Islands and Anticosti Island belong to this extension of the region. In this region, occur limestone, sandstone, and other beds of the Cambrian, Ordovician, Silurian, and Devonian periods. The region is bounded on the north by the rough country of the Precambrian Shield, and on the southeast by the hilly Appalachian region. With the exception of a few hills (the Monteregian) formed by igneous intrusions, such as Mount Royal, in Montreal, the St. Lawrence region is a flat, low-lying plain, at Montreal about 70 miles wide. There are outliers of Ordovician beds north of Quebec city and in the Saguenay River and Lake St.

John areas. There are also Paleozoic outliers west of Ottawa and on Lake Temiskaming.

THE APPALACHIAN REGION

The **Appalachian Region** lies east of a line from the foot of Lake Champlain to Quebec city and on down the St. Lawrence. It thus includes the parts of the province called the Eastern Townships and the Gaspé peninsula, together with a narrow strip along the Maine and New Brunswick boundaries. The Appalachian region is a continuation northeastward of the Green Mountains of Vermont and White Mountains of New Hampshire. Sutton Mountain near the Vermont boundary is 3,100 feet above sea level. In Quebec the folding has produced three parallel groups of hills and ridges separated by distinct valleys. The western range extends the whole length of the region, from the Vermont border to the Gaspé peninsula, where it reaches heights of 3,400 to 4,200 feet. In the Eastern Townships the axis of this range is composed of schists thought to be Precambrian in age. The flanks of the hills are formed of metamorphosed Cambrian sedimentaries, including slate, limestone, quartzite, and volcanic fragmental rocks. Ordovician beds of shale and sandstone occur among the folded and faulted layers all the way from the foot of Lake Champlain to Quebec city and beyond. Ordovician slate, quartzite, and conglomerate form a zone sometimes 20 miles wide along the southeast side of the St. Lawrence from Levis to the end of the Gaspé peninsula. These beds are much folded and faulted. In southeastern Quebec, limestone, slate, and conglomerate of Silurian age are found, and in some places these are followed

by Devonian shale, limestone, and conglomerate. Both Silurian and Devonian sedimentaries are extensively developed in the Gaspé peninsula, and consist largely of shales and limestones.

Towards the close of the Devonian period, the Appalachian region was subject to mountain building forces with folding, faulting, and intrusions of granite, now bared by erosion both in the Gaspé peninsula and in the southeastern part of the province. There are also intrusions of basic rocks that may be older than the granite. The folds have a general northeast-southwest direction, following the valley of the St. Lawrence.

Carboniferous beds, so extensive in New Brunswick and Nova Scotia, are found in Quebec only as a narrow selvage along the south shore of the Gaspé peninsula.

The ice sheet that glaciated the northern part of the continent did not cover the heights of the Gaspé peninsula, where the rock débris lies undisturbed, and often to a great depth. The glacier also left undisturbed certain gravel beds of preglacial rivers in the Eastern Townships, and some of these gravels, as along the Chaudière River have proved to be auriferous. The protection of these gravels from the advancing ice seems to have been due to the direction of the deep valleys across that of the ice moving from the northeast.

THE PRECAMBRIAN REGION

Quebec includes all that part of the Precambrian Shield lying east of Hudson Bay, except the Labrador Coast belonging to Newfoundland. The Paleozoic rocks

that lie south and west of Hudson and James bays are continued across the boundary into Quebec, where they form the west shore of Rupert Bay. Otherwise the boundary between Ontario and Quebec is in Precambrian country until it reaches the Silurian-Ordovician outlier at the head of Lake Temiskaming, after which it follows the Ottawa River through Precambrian territory until the Paleozoic beds of the Ottawa-St. Lawrence region are reached. This great territory is in the form of a rough triangle with its base of 1100 miles along the St. Lawrence river and gulf, and its apex on Hudson Strait about 1100 miles north of Montreal. The greater part of this territory, about 600,000 square miles in extent, is geologically mapped as "Precambrian, unclassified, mostly granite and gneiss," but there are also many areas, some of them large, that are unclassified Precambrian, but known to include sedimentary series, as well as volcanic and plutonic igneous rocks. On closer examination these areas may be resolved in part into those assemblages of rocks that have proved so productive in Ontario. These are well represented in the better known parts of Northwestern Quebec adjoining Ontario. The large belt of Keewatin, Timiskamian, and Algoman rocks that includes the Porcupine and Kirkland Lake gold areas in Ontario continues eastward in Quebec beyond Bell River. On the Quebec side this mineral belt has already been shown to be important both for gold and the base metals. A long tongue from this belt connects it with the Chibougamau area where promising discoveries of gold and copper ores are being developed. Northeast of Chibougamau Lake

are later Precambrian rocks characteristic of the silver and nickel-copper areas of Ontario. North of the Porcupine-Kirkland Lake-Rouyn region is the next largest area known of the older Precambrian rocks in which the best gold discoveries have been made. It stretches from the Abitibi River to Gull Lake about 30 miles east of the Bell River. The greater part of this area is in the province of Quebec. Its broadest part is traversed by the Harricanaw River. Smaller areas of these rocks occur along the Nottaway, the Broadback, and the Eastmain rivers, on the east side of James Bay. Other small areas have been mapped along the east side of Hudson Bay.

The district immediately north of the St. Lawrence region between Ottawa and Quebec City is underlain mostly by unclassified Precambrian rocks including sedimentaries, and volcanic and plutonic igneous rocks. Crystalline limestone is frequently seen, and also quartzite and rusty-weathering schists, all characteristic of the Grenville series. The crystalline limestone is more plentiful in the western part of the area. North of Montreal, a large intrusion of anorthosite is seen, the southern edge of which is in contact with the overlying Paleozoic. Farther east an immense anorthosite intrusion begins east of Lake St. John and stretches northward to the Natashkwan River.

Smaller masses of basic intrusives occur around the headwaters of Hamilton and Beaver rivers. Near these headwaters occur some small areas of early Precambrian rocks of the gold-bearing series, and here begins a broad band of later Precambrian that can be followed northwestward down the Koksoak River be-

yond its junction with Larch River. Smaller areas ot these rocks are found eastward around the headwaters of the George and the Naskaupi Rivers. This region is thought to be geologically favorable for prospecting.

CHAPTER III

METALLIC MINERALS

GOLD, SILVER, PLATINUM

The mineral production of Quebec has so far not been characterized by great diversity, but the geology of the province leads to the expectation that diversity will be increased by the discovery of economic minerals not hitherto produced.

In describing the mineral deposits of the province, they are divided into two classes (1) **metallic** and (2) **non-metallic.** Metals and ores of metals are put in the metallic division, and minerals not used as ores of metals, in the non-metallic, even though the properties of the minerals themselves may be metallic. For example, pyrite is described in the non-metallic class, because its use as a source of sulphur puts it there, although it has the metallic appearance and contains a metal, iron. The ores of a metal are described under the heading of the metal, as, for example, hematite, magnetite, limonite, and siderite under the heading **Iron.**

The precious metals, gold and silver, are taken first, and with them the rare and very valuable metals of the platinum group. The order after that is roughly the order of importance in production of metals, ac-

tual and possible. Ores are described that under present circumstances are not being used. The circumstances may change and bring them into use. Ores not yet discovered in Quebec are referred to when the geology of the province is favorable for their occurrence.

GOLD

Gold Epochs

There were probably four epoches of gold deposition in Precambrian rocks. To begin with the oldest, doubtless the extensive intrusion of **Laurentian** granite and other igneous rocks into the Keewatin and Grenville formations led to the deposition of gold, but the erosion of succeeding ages has removed most, if not all of them. The erosion of the Laurentian mountains must have formed extensive and widespread gold placers, but these along with others formed in subsequent periods have been scattered by glacial action. Some of them may possibly have been preserved as conglomerate rock. Some less important gold deposits seem to have been formed in connection with intrusions of basic rocks of **Haileyburian** age, younger than the Laurentian but older than the Algoman intrusives. The gold deposits so far discovered in Northwestern Quebec are associated with intrusive granite, etc., of an age thought to be the same as that of the **Algoman** intrusives of the Ontario gold fields farther west. Masses of granite, syenite and porphyry have broken through the Keewatin greenstone, schists, etc., and the Timiskamian conglomerate, slate, quartzite and graywacké. The fourth epoch of gold deposition is

the **Keweenawan**. The gold deposits associated in Ontario with the intrusives of this period are small and none of them are now productive. The veins are mostly in close association with dikes and other masses of diabase, gabbro, etc., that have broken through sedimentary rocks of Animikean (Cobalt) age and therefore must be younger than these.

It is at once obvious that the Algoman epoch of gold deposition exceeds all the others in importance, and prospecting for gold should therefore be directed to those areas where assemblages of Keewatin lavas, greenstones and schists, Grenville gneiss, schists, etc., and Timiskamian conglomerate, slate, etc., have been intruded by granite, syenite, and especially porphyry. The important gold ranges are commonly indicated by long, narrow strips of Timiskamian sedimentary rocks, which are the remains of those rocks that once formed the outer shell of mountains ranging between east and west, and northeast-southwest. The removal of these mountains laid bare the mineral deposits that had been formed deep down beneath their flanks. This denudation left the Timiskamian sedimentary rocks and the underlying Keewatin lavas and schists lying side by side representing the lower parts of the folds. It follows that a gold discovery can often be repeated many times by following these elongated structures in an easterly or westerly direction. The best prospecting ground is found around the smaller masses of granite, syenite, and porphyry, rather than in the neighborhood of the masses that extend unbroken for many miles. Erosion has removed the deposits that may have gathered at the tops of these

larger bodies, but has been less severe over the places where the smaller patches show. But long tongues of granite, etc., projecting from the main body, may be favorable. The veins and shear zones that may carry gold most commonly follow the general strike of the country, shown by long narrow bands of rocks, ridges, long lakes, and other features of the surface. There is often a well marked line of break running for miles in a definite direction, and the veins are apt to follow this line.

Types of Gold Deposits

According to the metallic minerals accompanying the gold and the nature of the gangue minerals, gold deposits may be classified into the following types:

1. **The pyrite-gold-quartz type** in which the chief metallic mineral is pyrite and the main gangue mineral is quartz. With the pyrite there may be smaller quantities of copper pyrites, zinc blende, galena, pyrrhotite, magnetite, mispickel, bismuth minerals, tellurides, molybdenite, scheelite, native copper, tellurides, etc., and the gangue minerals may be represented in small part by calcite, barite, tourmaline, feldspar, etc. The gold usually occurs with finely divided pyrite, calcite, and chlorite in thin cracks in the quartz, and with small grains of pyrite in the schist. This is the commonest and most productive type.

2. **The mispickel-gold-quartz type** in which the chief metallic mineral is mispickel. Many of the gold deposits of the Rouyn area are of this type.

3. **The gold-tellurides type** in which the gold is accompanied by tellurides, a family of minerals com-

posed of tellurium combined with certain metals. Some of them are tellurides of gold or of gold and silver, and their presence increases the gold values in the ores. It at the same time causes some difficulty in extracting the whole of the gold.

4. **Gold-calcite type** includes deposits in which calcite is the principal gangue mineral. There may be small quantities of quartz, and the metallic minerals may be represented by pyrite, copper pyrites, galena, zinc blende, etc.

5. **Copper-gold type,** represented by the Horne mine and other ore bodies of the Rouyn district.

Gold deposits can be classified according to shape and relation to surrounding rock.

1. **True fissure or simple vein** is a body of ore filling a single, long, narrow space, the well-defined walls of which are approximately parallel. Such veins are apt to occur in compact rocks rather than in those that have been weakened by compression into schists.

2. **Composite veins or lodes.** These are made up of a number of nearly parallel lenses of ore more or less connected by cross veins the rock between being often partly converted into ore. The number of veins is sometimes very large, taking in a wide space and great length.

3. **Sheeted zones.** A large number of very narrow parallel veins or veinlets closely **spaced.**

4. **Stockwork.** Stringers of ore irregularly placed in the rock, more or less like a net-work. Apt to occur in the more compact rocks like granite, porphyry, dolomite, and ankerite.

5. **Fahlbands or Shear zones.** These are bands or zones of rock that have been shattered and squeezed so as to be more or less converted into schists. The crevices are filled with pyrite and other sulphides, and there may be very little quartz. These bands are sometimes very wide, but payable gold ore is usually restricted to parts of them.

6. **Single lens or pipe.** This is a body that has little length in proportion to its width and depth.

In gold deposits the gold content may vary in the same ore body. This variation often occurs in such a way as to form a rich zone descending vertically or with a slope (pitch). This rich part of the vein or other deposit is called the **pay shoot.**

Rocks in which gold deposits are found

The most productive deposits are in Keewatin schists and Timiskamian sedimentary rocks in the neighborhood of intrusions of porphyry, granite, and syenite of Algoman age. Some gold has been produced from veins in granite and syenite.

GOLD IN QUEBEC

PLACER DEPOSITS

In 1835 it was made known that nuggets of gold had been found in the valley of the Chaudière River, in a branch of that river, the Touffe des Pines or Gilbert. A large nugget weighing about 1070 grains was picked up a few years before 1835, but it is recorded that a nugget had been found before this, about 1824. These discoveries at first attracted no attention, but

gradually the habitants and land owners began to search for gold, and with such encouraging results, that larger operations were attempted, with varying success. Some large nuggets were found on the North Branch of the Gilbert river, one weighing over 52 ounces. Some of the companies working on the Gilbert, du Loup, Famine, and other branches of the Chaudière took out large quantities of gold with profit. Others, less skilful or less fortunate, were not so successful. It is estimated that the placers of the Chaudière region have yielded gold to the value of about $3,000,000.

Auriferous gravel has been found in places in Southeastern Quebec over a region extending from Memphremagog Lake on the west to the Etchemin River and township of Ware on the northeast. The northwest boundary of this area is the Sutton Mountain anticline, the range nearest the St. Lawrence River. The gold-bearing gravels have been found as far southeastward as the United States boundary. This district is estimated to measure between three and four thousand square miles. Within its limits there are areas barren of gold, and others where the quantity is too small to be of economic importance. While a little scattered gold has been found in glacial and later deposits, these materials are usually barren. Their occasional gold content is evidently derived from the rewashing of the pre-glacial gravel in which the gold is mostly found. This gravel usually lies on bed-rock, which is often slate between the layers of which the gold may have worked down several feet. The gold-bearing gravel is in the valleys of pre-glacial streams,

the courses of which are partly followed by the modern rivers and branches. Where these pre-glacial gravels have been cut through by the streams of today, as along the Chaudière and its branches, there is sometimes a re-concentration of the coarser gold in the gravel and rock crevices in the beds of these streams. It is possible that there are in the area ancient river beds left dry and undisturbed by modern streams, but a large amount of prospecting has failed to disclose pay gravel at higher levels than the beds of present day streams. The presence of great depths of boulder clay and fine sand in some places overlying the gold-bearing gravel makes mining difficult. In most valleys the rivers of today have not cut down to the bottom of the pre-glacial gravel. It is possible that this deep-lying gravel may be profitably worked.

CHAUDIERE AREA

The greatest amount of gold has been taken from the Chaudière and its branches, particularly from the gravels of the Gilbert or Touffe des Pines River. It is thought that modern dredging and hydraulic methods could still be profitably used in the Chaudière section.

Gold has not been found in the Chaudière valley below Bisson, two or three miles north of Beauce Junction, but it occurs everywhere above that point both in the Chaudière valley and in the valleys of its branches.

DITTON AREA

A good deal of gold has been taken from the gravel of Little Ditton River, a branch of Ditton River, a

branch of Salmon River which in its turn flows into the St. Francis River. The diggings in this area have the advantage of a comparatively light glacial overburden covering the gold-bearing gravel, but the glacial deposits are heavy in other parts of the Ditton and Salmon valleys. Alluvial gold has been reported as occurring in branches of the Salmon River flowing southward from Big Megantic Mountain.

DUDSWELL AREA

The Dudswell area is between Dudswell Lake and Ascot Corners, on the eastern and southeastern slopes of Stoke Mountain. All the streams flowing down these slopes have been shown to have gold-bearing gravels. Some large nuggets have been taken from diggings on Kingsley Brook. In the Hall Brook, blocks of quartz showing gold were found. The gold is found mostly in the undistured pre-glacial gravel, and in the crevices of the schists and slate on which it lies, but it has also been taken from the sand and clay in which it has been concentrated by the action of the present day streams.

LAMBTON AREA

Some gold has been taken out of placers in Lambton township. Gravel resting on decomposed slate in the valley of a small stream near Lambton village carries enough gold to pay, but the extent of the auriferous gravel seems to be small.

ASCOT AREA

In Ascot townships there were several large undertakings from 1863, to 1865 one on Grass Island Brook,

and another on lot 11 of the ninth range. Gold was found in gravel resting on slate, but the extent of the gold-bearing gravel seems to have been small.

ORFORD AREA

In Orford township, attempts were made to win gold from the gravel of small branches of the Magog River, but without success. The gold is distributed irregularly and in small quantities only.

HATLEY AREA

Placer gold has been found in small quantities in the valley of a small stream emptying into **Massawippi Lake** on its west side. This lake is in Hatley township, Stanstead county. Several attempts were made to work the gravel in this valley, but without profit. In the slaty and talcose rocks forming the bed of the stream, there are irregular seams of quartz carrying sulphides, but assays showed them to be barren of gold.

GOLD VEINS AND SIMILAR DEPOSITS

Eastern Townships

Quartz veins occur in the Precambrian and younger rocks in the placer gold areas of the Eastern Townships. The majority of these veins are barren, but some of them carry appreciable amounts of gold. It is thought that the gold-bearing veins may be the source of the placer gold. Attempts have been made to mine some of these gold veins, but apparently without profit.

Near Lake Megantic, Marston township, gold occurs in dikes of fine-grained somewhat porphyritic gran-

ite. The dikes are within a mile of Victoria Bay, a westerly expansion of the lake, and intrude sedimentary schists and slaty rocks of Ordovician age. Copper pyrites, pyrite, and galena are seen in the dikes, which have been much broken and schisted in places. The cracks are filled with quartz. Gold was found both in the quartz and in the rock. The dikes are from 15 to 20 feet wide. Assay of a grab sample gave $7 a ton in gold.

TOWNSHIPS OF CHERTSEY AND KILDARE

These townships are in the area north of the island of Montreal that is largely underlain by the great mass of anorthosite called the **Morin Anorthosite**. In this rock are many quartz veins carrying pyrite. A good deal of work has been done on some of these veins, but assays show that they are barren of gold.

Western Quebec

That part of Quebec lying east of the Ontario boundary and including large parts of the counties of Témiscamingue and Abitibi is traversed from west to east by a broad band of early Precambrian rocks continuous with that in which lie the gold mines of Porcupine and Kirkland Lake in Ontario. This band continues eastward a little beyond Bell River. The part in the province of Quebec forms a block about 110 miles long and 80 miles wide. About two thirds of this block lies south of the Transcontinental line of the Canadian National railway. This large area of mineral country has been vigorously prospected for the last seven years. Before that time it had been tra-

versed in places by prospectors, and discoveries of gold had been made near De Montigny Lake, in Rouyn township, at Lake Fortune in Boischatel township, and at several other localities. But these discoveries were not sufficiently important to attract the attention given to the Horne and other discoveries in Rouyn township when they became generally known in 1923. Since that time large deposits of copper-gold ore have been brought to production, one gold mine, the Siscoe, has begun to produce and several others are approaching production.

The region under consideration is traversed from west to east by a band of partly schisted conglomerate and graywacké of the Timiskamian series. These rocks lie largely in the southern part of the region, crossing the townships of Dasserat, Boischatel, Rouyn, Joannes, etc. The Timiskamian belt is 10 or 12 miles wide in Dasserat and Boischatel townships, but only 1½ mile in part of Dufay township where a large granite intrusion narrows it on the south side. Cobalt sedimentaries conceal the contact with the Keewatin volcanics in parts of Dasserat and Boischatel townships. Quartz veins carrying gold have been discovered in the sedimentary rocks where they are intruded by granite and acid porphyries, and also in the Keewatin volcanics north of the Timiskamian sedimentaries. The discoveries of large bodies of copper ores, some of which carry important values in gold, have been made in the Keewatin volcanics skirting the sedimentary rocks along their northern side. (See **Copper** p. 65).

As in the corresponding goldfields in Ontario, many of the gold veins are associated with syenite and syenite porphyry. There are numerous porphyry dikes in the Keewatin between lakes Renaud and Osisko, and also in the Timiskamian sedimentaries farther south, where the intrusions sometimes take the form of sills. In the same area are syenite dikes, rather fine-grained, and in many places strongly mineralized with pyrite and carrying \$2 to \$3 in gold. It is considered that the best prospecting ground is in the northern mile or mile and a half of the Timiskamian belt, and in the Keewatin volcanics four or five miles north of this.

DASSERAT TOWNSHIP

Discoveries have been made near the inter-provincial boundary at Labyrinth Lake (Russian Kid claims) and at Lake Maron near Cheminis station on the Nipissing Central railway.

BOISCHATEL TOWNSHIP

The Arntfield property is about a mile and a half northwest of Lake Renaud. The ore bodies are replacments of Keewatin lavas by quartz, carbonates and other minerals. The lava flows strike east and west, and the ore bodies occur between the flows. The eastern ore body is up to 30 feet or more in width, and the western is still wider. The gold values vary. An extensive assay plan shows commercial ore over mining widths at a number of places.

The **Francoeur** claims adjoin the Arntfield on the west. The Francoeur ore body is similar to the Arntfield. The presence of a good deal of hematite gives

the ore a red color. The mineralized zone across the two properties is more than 6000 feet long.

The **Aldermac Mine** is more important as a copper mine than for the gold content of the ore, which is not large (See **Copper** p. 67 and **Pyrite,** p. 211).

Lake Fortune Mining Company's property is on Lake Fortune near the western boundary of Boischatel. A gold vein has been developed by surface and underground work. The vein is in a shear zone in basalt near an intrusion of syenite porphyry. It carries visible gold and tellurides. Molybdenite is also present. The vein is 6 to 12 feet wide. At the western end the sheared belt is 200 to 300 feet wide, but throughout the greater part of its length it carries very little vein material. The principal vein minerals are quartz, carbonates, fuchsite (chromium-lithium mica, of a green color), pyrite, copper pyrites, tellurides, and visible gold.

Huronian Belt claims are near the eastern boundary of Boischatel township, west of Pelletier Lake. The ore bodies are of the replacmement type in lava flows and tuffs. A vein 8 feet wide has been uncovered. A channel sample across 5 feet at the bottom of a 29-foot shaft assayed $15 a ton.

ROUYN TOWNSHIP

The most important ore bodies in this township are those of the Horne, which are very large bodies of copper ore with substantial gold values (See **Copper** p. 68).

The **Bathurst (Granada)** claims are in the southwest corner near the west boundary of Rouyn township. A large mass of feldspar porphyry intrudes Timiskamian conglomerate and graywacké. The porphyry is cut by many irregular veins of glassy quartz up to a foot wide. The quartz carries a small amount of pyrite and mispickel. There is a larger vein (up to 6 feet wide) in the conglomerate. This vein shows a good deal of gold in places, and the wall rock is strongly mineralized with mispickel. The property has been developed by a shaft 625 feet deep, and a good ore body is reported.

The **Chadbourne** vein in Block No. 1 on the property of Noranda Mines Ltd. is a quartz vein in Keewatin acid lavas cut by dikes of red feldspar porphyry. The vein is in an overturned fold of the lava.

Powell. The Powell property is in the northwest corner of Rouyn township on the southeast side of Héré Lake. A quartz vein from 6 inches to 15 feet wide, averaging about 5 feet, has been traced for about three quarters of a mile. Assays show values of $5 to $6 with richer ore shoots in places. The vein is partly in Keewatin greenstone and partly in a granite rock. The wall rocks show pyrite, carbonates, and a little copper pyrites and chrome-mica.

Rouyn Gold Mines, Ltd. This property is south of Pelletier Lake. There is a shear zone in Keewatin volcanics largely altered to carbonates and chlorite, with irregular quartz lenses carrying a little pyrite. The rock is mineralized with pyrite, and the gold values are mostly in this mineralized rock.

JOANNES TOWNSHIP

Development has been confined to properties in the northern part of the township where quartz veins occur in Keewatin lavas.

Brownell Exploration Company. The claims of this company are in the northeast part of the township. A 200-foot wide shear zone in andesite has been traced east and west for half a mile. In this zone are a number of quartz veins that pinch and swell from a few inches to 12 feet in width. One lens is 150 feet long with an average width of 3 feet. Pyrite and tourmaline are present in the quartz. A number of the veins carry good gold values locally, but only one narrow vein was found to carry consistent gold values for a considerable length.

Huronian Belt Company. The claims of this company lie south of Cléricy lake in both Joannes and Cléricy townships. There is a mineralized zone stretching across claim T-663 near its north boundary. The minerals are pyrite and a little copper pyrites, and the mineralization is almost continuous over the width of the claim.

Marillac Syndicate. The claims of this syndicate are in the northwest corner of the township. Quartz veins occur in a shear zone in granite.

Lowry. The Lowry claims are in the north part of Joannes township, just east of Lake Marillac. They are within the southern end of the Cléricy granite batholith. There are on the claims a number of small veins showing free gold. The largest is about 5 feet wide. Channel assays show good values.

MONTBRAY TOWNSHIP

Interesting discoveries of copper-gold ores have been made in this township, and several companies have done a large amount of development work. In the southeast corner of the township, the Hugh Park claims were optioned by Nipissing Mines, Ltd., and three mineralized zones were developed. In one of these, high grade copper ore was formed carrying $10 a ton in gold in places over a width of three feet. A width of 9 feet of high-grade copper ore was uncovered. Diamond drilling gave results not completely conclusive. The erratic values made it difficult to determine the size and value of the ore bodies.

DUPRAT TOWNSHIP

The **Waite-Montgomery** and other properties not so far advanced in development are of importance for their copper and zinc ores rather than for gold, (See **Copper** p. 70 and **Zinc,** p. 101) but on the claims of the **Towagmac Exploration Company** in the southwest quarter of the township are mineralized veins carrying considerable values in gold.

DUFRESNOY TOWNSHIP

The **Amulet,** the most important property in this township, is partly in the adjoining township of Duprat. The ore is distinctively a copper-zinc ore (See **Copper,** p. 71 and **Zinc,** p. 101,) but the gold values are considerable.

McDougall Mines, Limited. The claims of this company are east of the Amulet. Diamond drilling has shown a wide mineralized zone of low-grade copper ore (See **Copper,** p. 72) with values in gold.

CLERICY TOWNSHIP

This township adjoins Dufresnoy on the east. It is traversed by the Kinojevis River, and the Canadian National railway branch touches it on the west. The large amount of exploration work in this township has resulted in the discovery of mineralized zones carrying pyrite, copper pyrites, and zinc blende. Commercial ore is indicated on the claims of the Archean Mines Development Company, Limited, but the quantity is not known. The mineral zone is about parallel to the eastern contact of a long mass of granite that stretches through Clèricy and part of Joannes township.

DUPARQUET TOWNSHIP

This township is in the range north of Duprat and Dufresnoy. The rocks are mostly Keewatin andesite and other volcanics, but there is an east-west band of Timiskamian sedimentary rocks, (slate, arkose, and conglomerate), crossing the middle of the township. North of the west end of this band is a large mass of quartz porphyry and feldspar porphyry. There are smaller masses of porphyry intruding the andesite and the sedimentaries. The northern part of the township is underlain by schistose volcanic rocks and granite.

The **Silver-Prickett claims** south of Lake Dugros show extensive mineralized zones in which the rock is more or less replaced by pyrite, but the copper, gold, and silver contents are very low.

On **Beatty** island in Lake Duparquet there is a shear zone in basic volcanic rocks. The rock is much altered to carbonates, quartz, pyrite, and copper pyrites. Simi-

lar zones occur on the mainland on the **Berner-Bachmann** property. Adjoining this on the east are the **Brookbank** claims, where large tonnages of low-grade gold ore have been indicated by diamond drilling. The ore is in a zone of sheared lava intruded by acid porphyries. On the **Kellar property**, a mile and a half north of Duparos Lake, there are narrow veins and veinlets of quartz in red feldspar porphyry. The gold values in the quartz are high. The associated minerals are copper pyrites and mispickel.

DESTOR TOWNSHIP

This adjoins Duparquet township on the east. The geology of the two townships is quite similar.

Destor Mines, Limited, holds claims at the north boundary of the township, and 3½ miles east of the Government highway. There are mineralized zones in schistose lava. One of these is 32 feet wide showing much pyrite and disseminated copper pyrites.

LANDRIENNE TOWNSHIP

This township is on the same range with Duparquet and Destor townships. It lies east of the Harricanaw River.

The claims of the **Fisher Quebec Prospecting Syndicate, Ltd.,** are in the eastern part of the township and are crossed by the Canadian National railway. Exploration work has developed a zone of mineralization 1000 feet long. Bands of quartz and mineralized schist aggregating a width of 20 to 70 feet show gold contents of $1.40 to $34.00 in three-foot sections. Other mineralized zones have been discovered, in one of

which the quartz carries pyrite and tourmaline. The country rock is Keewatin greenstone.

BARRAUTE TOWNSHIP

This township adjoins Landrienne on the east of Landrienne. **Continental Gold Mines Syndicate** claims are on lots 9 and 10, range two. The discovery is in schisted porphyry, in which there are veinlets of quartz carrying tourmaline and visible gold. The **Fisher Quebec Prospecting Syndicate's** holdings extend from Landrienne into Barraute township, and a discovery of some promise has been made. The property of **La Mine D'Or Venus, Ltée** is in the southwest part of the township. Promising discoveries of gold have been made.

BOUSQUET TOWNSHIP

Bousquet township is east of Joannes. The township is underlain throughout the greater part by Timiskamian sedimentary rocks. The contact of these with Keewatin lavas is in the northern part of the township. The depression that marks the mineralized zone on the O'Brien claims in Cadillac township is continued on the **Montreal Exploration Company** claims in Bousquet, but the gold values are small.

CADILLAC TOWNSHIP

This township is immediately east of Bousquet. The band of Timiskamian sedimentaries crosses it from east to west. The southern part of the township is underlain by Timiskamian sedimentary rocks which are intruded by numerous bodies of granite, syenite, and acid porphyry. The **O'Brien** mine is in the northwest part of the township in the sedimentaries where

they are intruded by feldspar porphyry dikes and sills. There are bands of greenstone in the sedimentaries. Five veins have been located in a fault zone which on its western end forms a depression. Two of the veins carry much coarse gold in quartz associated mostly with mispickel. About 465 pounds of this ore shipped to the Royal mint, Ottawa, in 1926, gave a gold bar weighing 43.26 ounces, and a further 19.067 ounces was recovered from ore rejected at the Mint. The total value of this gold was about $1125. This property produced a small amount of gold in 1925.

The **Thompson-Cadillac Mine** lies between the O'Brien and the western boundary of the township. The veins are in the Timiskamian sedimentary rocks which are locally altered to talc-chlorite schist. There are intrusions of porphyry, aplite, and diorite. A mineralized zone 2 to 6 feet in width has been traced for 900 feet in the porphyry which is sheared and mineralized with sulphides and mispickel. Carbonates are plentiful in the rock. There is rich gold ore in places, particularly at the east and west ends of the zone. The gold is in quartz. Diamond drilling has located a three-foot section of $12 ore and six feet of $8 ore. The property has been developed by a shaft and drifts. An ore body of mining width is reported. A test run of 14 tons of ore taken out in course of development returned $140 in gold.

MALARTIC TOWNSHIP

This township is immediately east of Cadillac. Lake La Motte occupies a large part of the northern half of the township. Most of the southern half has

been staked. The geological features are much the same as in Cadillac township, but the Timiskamian sedimentaries swing to the south, and there is a correspondingly larger area in the north underlain by Keewatin lavas. Mispickel is commonly present in the quartz veins.

Knox Syndicate. On lots 11 to 14, range two, an intrusion of porphyry cuts Timiskamian graywacké. Quartz veins with galena cut the porphyry which is mineralized with pyrite over a width of 15 feet. The quartz with galena gives high gold and silver assays.

Lartic Mining Corporation, Limited. The property of this company takes in a number of lots in ranges three and four. On lot 4, range three, there is a sheared zone 400 feet long with a maximum mineralized width of 40 feet. In the centre of this is an enrichment 12 feet wide that gives the best assay results. An important body of quartz has been found on lot 1, range three. A shaft has been sunk and underground development is going on.

National Exploration and Holdings Co. The claims of this company are in range one, along the boundary of Fournière township. On lots 46 and 47, a promising show of gold ore is reported. A vein 4 to 21 feet wide has been traced for a length of 375 feet. Assays from \$2.65 to \$12.60 have been obtained over commercial widths. The vein is at a contact between quartz porphyry and graywacké.

FOURNIERE TOWNSHIP

Fournière township lies south of Malartic. It is underlain by rocks of the Timiskamian series, mostly

graywacké and schist. These rocks are intruded by numerous masses of granite, syenite, and acid porphyries, one large mass occupying the southwest part of the township.

Malartic Mining Company. The property of this company is in the northwest corner of the township near the boundary of Malartic township. The sedimentary rocks are intruded by syenite porphyry. The sediments have been silicified, and mineralized with pyrite, copper pyrites, and galena. Gold is also present. There is a small amount of mispickel. There has been a large amount of diamond drilling and trenching done on the property, and important bodies of gold ore have been indicated.

Fournière Gold Mines, Ltd. This property is a mile and three quarters from the Malartic boundary in the northwest part of the township. Gold was discovered on the property by W. D. Gouldie in 1923.

DUBUISSON TOWNSHIP

This township lies immediately east of Fournière. The southern part of the township is underlain by sedimentary rocks of the Timiskamian series. The contact with Keewatin volcanic rocks crosses diagonally from northwest to southeast. Lake De Montigny occupies a considerable portion of the northern part and extends northward into Varsan township. Intrusive masses of granodiorite occur in the northern part of the township, and the gold deposits near Lake De Montigny are probably connected in origin with these intrusives.

Prospecting in this township and others in the Harricanaw River basin has been going on at intervals since the construction of the Canadian National railway through the region.

Siscoe Gold Mines, Limited. The principal holdings of this company are on Siscoe Island in Lake De Montigny. This island is mostly in Dubuisson township but extends northward into Varsan township. Gold was discovered on lot 39, range one, of Varsan, during the early prospecting in 1911 and 1912. The principal part of the property is in range ten of Dubuisson township. The rocks underlying the greater part of the island are volcanic, (lava flows and tuffs of intermediate to basic composition). In the northern part is a mass of granodiorite. Gold has been found both in the granodiorite and in the volcanics. All these rocks are cut by dikes of feldspar porphyry. Gold is found in systems of narrow veins and stringers, which are filled with quartz, tourmaline and, in some places, sulphides. There is a good deal of carbonates in the rock, and calcite and other carbonates occur in the veins. Several shafts have been sunk, a large amount of drifting and cross-cutting done, and lately the first gold mill in Northwestern Quebec has been built, and put in operation at the end of January, 1929. For the first month's run, the output was reported as $24,330 and, for the second month, $34,500. The mineralization has been picked up on the mainland north of Siscoe Island, and that part of the property is under development. Here, on lot 39, range one, Varsan township, a mineralized zone 100 feet wide has been uncovered. The country

rock is granite, somewhat porphyritic, and mineralized with pyrite and carbonate. Within the zone are networks of glassy quartz carrying pyrite and a little free gold. Tourmaline occurs in seams up to 3 inches wide.

Unison Gold Mines, Limited. The property of this company includes lots 27 and 28, range eight, Dubuisson township. A gold vein has been developed by shaft and drifts. Assays show good values over mining widths. The width of the vein varies from 3 to 14 feet. It has been drifted on for 550 feet on the 100-foot level.

Greene-Stabell. This property is on the same zone of mineralization as the Siscoe. The claims are on lots 53 to 58, range eight. A shaft has been sunk 600 feet and a large amount of drifting, cross-cutting, and raising done. The ore thus blocked out is reported to average $13.50 a ton. The country rock is much altered Keewatin basalt cut by many dikes of granodiorite porphyry. There are a number of quartz veins with copper pyrites and pyrrhotite. Gold values are mostly in the copper pyrites. The quartz is in a succession of lenses 1 to 3 feet wide, constituting a zone that has been followed 1000 feet. The schist next to the quartz carries sulphides, and assays $4 to $5 in gold. In one place the mineralized zone is 20 feet wide or more. The vein is cut by a granodiorite dike. Near the dike the gold values are from $10 to $40 a ton.

Sullivan Gold. This property in Dubuisson township has been explored by diamond drilling, and a number of important veins have been cut. Assays indicate a

sufficient tonnage of ore to justify underground development.

BOURLAMAQUE TOWNSHIP

This township lies immediately east of Dubuisson. The gold veins are in sedimentaries intruded by acid and basic dikes, similar to those in Dubuisson.

Clark-Read Syndicate. The claims of this syndicate are in the north west corner of the township, and three, or four miles east of the Greene-Stabell property. There have been uncovered two veins about 1,200 feet apart. One is of quartz, 6 feet wide, and showing an unusual amount of free gold. There are tourmaline, hornblende, and pyrite in the quartz, with a little copper pyrites. The other vein is a wide net work of quartz stringers in a rock breccia. In places there are quartz veins several feet wide. The quartz carries hornblende and tourmaline. Wall rocks and breccia are mineralized with much pyrite and also some copper pyrites.

LOUVICOURT TOWNSHIP

This township is east of Dubuisson. It is traversed by the Bell River. Gold has been discovered near Simon Lake.

HARRICANAW RIVER

Gold occurs in ferruginous dolomite on the left bank of the Harricanaw River, 14 miles north of Allard portage. There are small stringers of quartz in the dolomite, and parts of the rock where these are visible give high assays ($77.20). The dolomite passes gradually into quartz porphyry.

GENERAL

Small irregular, gold-bearing quartz veins have been reported from La Reine, La Sarre, and other northern townships, indicating deposition of gold over the whole 80-mile width of the Timiskamian-Keewatin area betwen the Ontario boundary and Bell River. The description of discoveries in the townships show that gold deposition has taken place throughout the length of this area, about 110 miles. The discovery of the Horne copper-gold deposit and other similar large and valuable bodies of copper ore drew attention from the discovery and development of gold mines. But doubtless there will be renewed activity in that respect, as soon as one or two gold properties come to profitable production.

References: Reports of the Geological Survey of Canada, and Bulletins of the Bureau of Mines of Quebec.

SILVER

The greater part of the world's silver production comes from ores of lead, zinc, and copper, and particularly from lead-zinc ores. In the reduction process, the precious metals go with the base metals and are recovered in various ways in refining.

The principal silver minerals are described at page 5. In the ores of lead and zinc, the silver is mostly part of galena and zinc blende, but in very rich ores, it may appear as argentite, the sulphide of silver, and occasionally native silver is seen in lead and zinc ores.

The production of silver in the Province of Quebec has so far been from lead-zinc ore. Native silver has not been found in economic quantities. The geological formations characteristic of the silver areas on the Ontario side of the boundary are found in Quebec in Fabre township east of Lake Temiskaming. A number of calcite veins mineralized with smaltite and niccolite have been discovered, and hopes were aroused that a silver area similar to that of Cobalt might be developed. But, although a little silver was found in a few of the veins, most of them proved to be barren of that metal. A large proportion of the Ontario veins carry silver, and this fact rather discourages the hope that silver in paying quantities may yet be discovered in Fabre township. On the other hand, it should not be forgotten that in the Gowganda silver area there are a great many barren calcite veins with only a few exceptional veins carrying a paying quantity of silver.

Native silver has been found in small quantities in the zinc-lead ore of the Tetreault mine at Montauban, and also in a similar ore deposit on Calumet Island (See pp. 102 and 104).

The copper ore of the Horne mine (Noranda), the Waite-Montgomery, Amulet, and others being developed in the Rouyn area, carries values in the precious metals, mostly gold, but the large scale of the operations at the Horne will account for a considerable production of silver.

The copper ores of the Eastern Townships carry small values in silver. As early as 1849, silver was noted in the ore at Ascot and Upham. The average

from the Capelton mines was 3 to 4 ounces per ton, but ore has been taken out of some mines with a much higher silver content.

Small galena veins high in silver are known in several localities in the province. That at Baie St. Paul has been known since 1830, but the quantity is too small to be of importance.

At the Devil's Rapid, on the Chaudière River, is a quartz vein mineralized with zinc blende, galena, etc. Samples of the minerals assayed 37 and 256 ounces of silver to the ton. In the same region, in the townships of Risborough and Marlow, on the Du Loup River, a branch of the Chaudière, are a number of quartz veins in slate and quartzite that have been intruded by basic dikes. Some of these veins contain considerable proportions of galena with high silver content. The veins are small, ranging from eight to twenty inches in width. Specimens of the galena assayed from 43 to 430 ounces of silver per ton. Some of these veins have been explored by sinking shafts to small depths.

Near the city of Sherbrooke a galena vein was opened up in 1888 and a shaft sunk, but as the ore was found to carry only about 9 ounces of silver a ton, the enterprise was abandoned.

The ore of the Wright mine on Lake Temiskaming carries about 18 ounces of silver per ton (See **Lead** p. 97).

At Little Whale River on the east coast of Hudson Bay, there is a deposit of galena in limestone, the ore carrying 5 to 12 ounces of silver per ton (See **Lead** p. 100).

Some of the zinc-lead deposits discovered in the Rouyn area are reported to carry substantial values in silver.

The Tetreault Zinc mine in Portneuf county has been the principal producer of silver in the province of Quebec. The ore carries 8.3 ounces of silver per ton. (See **Zinc** p. 103).

The total production of silver in Quebec in 1928 was 909,025 ounces, valued at $528,796.

References: Geological Survey of Canada, Annual Report, Vol. IV, 1888-89, p. 77K.

Bulletins of the Bureau of Mines of the Province of Quebec.

PLATINUM

Platinum and osmiridium have been found in small quantities in the gold-bearing gravel of Rivière du Loup and Rivière des Plantes, Beauce county. This gravel is 30 miles southeast of the serpentine belt where the platinum has its natural habitat in the dunite and peridotite. A nugget of platinum has been found at Plattsburg, N.Y., 50 miles south of the serpentine belt in Brome from which it may have been derived.

CHAPTER IV

METALLIC MINERALS (Cont'd)

COPPER, NICKEL, COBALT

COPPER

Ores. The principal ores of copper are **native copper; copper pyrites** or **chalcopyrite,** composed of copper, 34.5%, iron, and sulphur; **bornite,** copper, 50 to 70%, iron, and sulphur; and **chalcocite,** copper 79.8% and sulphur. A number of other copper minerals are sometimes found in sufficient quantities to be of use as ores. **Tetrahedrite** or **gray copper ore** is composed of copper, 52.1%, antimony, and sulphur. It may carry silver or mercury in important amounts. **Malachite** and **azurite,** the carbonates of copper form the green and blue stains and crusts that are sometimes a guide to the underlying sulphides or other ores of copper. The carbonates are formed by the weathering of the sulphides, etc., and while they may occur in important amounts in countries where weathering has extended to considerable depths and the products have not been removed by erosion, the glaciation of Quebec has carried away at least the majority of such deposits. **Cuprite,** or **red copper ore,** is an oxide of copper containing 88.8% of the metal. **Tenorite** or **melaconite** is another oxide, black in color. **Covellite** or

indigo copper is a rather rare sulphide of copper. Other minerals containing copper are **bournonite**, composed of lead, copper, antimony, and sulphur, **tennantite**, and **enargite**, composed of copper, arsenic, and sulphur.

In describing the distribution of copper minerals in Quebec only those occurrences are mentioned which are either of some economic importance or may indicate the advisability of further exploration in their neighborhood.

EASTERN TOWNSHIPS

The copper area of the Eastern Townships lies between the New Hampshire-Vermont boundary and the Chaudière River, in that part of the province that is a continuation northeastward of the Green Mountains of Vermont and the White Mountains of New Hampshire. The area is characterized by three parallel ranges of hills and ridges the axes of which are composed of schists of igneous origin thought to be Precambrian in age. From east to west the belts are (1) The Ascot, (2) The Sutton, and (3) The Acton. These belts are from 2 to 10 miles wide, and about 25 miles apart. Their northeast strike conforms with the great fault lines of the St. Lawrence valley.

The copper ores occur only in or in close association with Precambrian rocks of igneous origin, now altered to schists. The copper minerals are found mostly in slaty micaceous and talcose schists rather than in those of more basic types. The ore minerals are copper pyrites, bornite, and chalcocite, usually with such a large proportion of pyrite that the ore is used as a

source of sulphur, the copper being extracted from the cinder after the sulphur is burned off. (See **Pyrite** p. 208).

From the point of view of rock associations, the copper ore deposits of the Eastern Townships may be divided into three classes:

I. Deposits in schists mostly of igneous origin and both acid and basic in composition. The ore minerals are copper pyrites with a little bornite and chalcocite, and commonly a large proportion of pyrite.

II. Deposits associated with intrusions of serpentine, peridotite etc. The ore consists of copper pyrites in pyrrhotite and pyrite.

III. Deposits associated with intrusions of diabase in limestone. The ore minerals are copper pyrites with a little bornite, chalcocite, and occasionally native copper. The gangue is calcite with some pyrite.

I. Deposits in Schists. These are the most numerous and important. They occur in three schist belts (1) The Sutton, the most western, running from the Vermont boundary to the Chaudière River, a distance of about 140 miles; (2) The Ascot, nearly 70 miles long, running from the Vermont boundary northeast through Brome, Sherbrooke, Wolfe, and Megantic counties, and (3) The Lake Megantic belt, about 20 miles long.

The Sutton belt is made up largely of chlorite and sericite schists that have apparently been formed from a variety of rocks both igneous and sedimentary. Iron and copper sulphides occur frequently and many discoveries are recorded. Over 300 had been reported by

1866. More than twenty of these have been considerably developed and have produced more or less ore. The largest producer has been the Harvey Hill mine in Megantic county. It was operated for about thirty years. The ore body is in schist of sedimentary origin. There is an intrusion of pyroxenite in one of the shafts, and it has been suggested that this rock, characteristic of the serpentine-asbestos country, may be the source of the sulphides. The ore bodies are lenses running with the strike of the schists. There are no true veins. The ore minerals are copper pyrites, bornite, and chalcocite.

In the Ascot-belt are the largest and most persistent producers, the Eustis and Capelton mines. (See **Pyrite** p. 208). The rocks are largely mica and other schists, and sometimes sheared quartz porphyry. Southwest of Sherbrooke, the schists are altered intrusive rocks. The Weedon mine, northeast of Sherbrooke, is in schists near an intrusion of granite. In this productive zone west of the St. Francis River, it is perhaps significant that there are evidences of long-continued volcanic activity from Precambrian into Ordovician times.

The Lake Megantic schist zone has not been much prospected. The schists resemble those of the Sutton belt.

II. Deposits in Serpentine, etc. Copper ore has been found in basic rocks such as serpentine, peridotite, pyroxenite, and diabase, that are characteristic of the serpentine-asbestos belt. These rocks are younger than the copper-bearing schists of the Sutton and Ascot belts. They form an irregular band east of the Sutton

belt. The deposits are often composed mainly of pyrite and pyrrhotite. The ore mineral is copper pyrites. The sulphides are commonly in the dikes and other intrusive masses of diabase, etc. The Huntingdon Mine, in the township of Bolton has been the largest producer. The Orford Mountain branch of the Canadian Pacific railway now crosses several of the properties. During the early developments on this belt, transportation facilities were very poor.

III. Deposits in Limestone. In a zone that extends about 100 miles southwest of Levis, copper ore deposits have been found in limestone of Trenton (Ordovician) age, associated with intrusions of diabase. The area is about 20 miles west of the Sutton range. The ore minerals are in some places found in the diabase. The minerals are copper pyrites, bornite, chalcocite, and occasionally native copper, with more or less pyrite. The largest deposit was found in the Acton mine, where very rich ore occurred in limestone at its contact with diabase. The underlying graphitic shale did not yield much paying ore.

"With so many occurrences of copper already found, and the experience of past work as a guide in selecting them, prospecting would be largely detailed work —stripping, shallow rock cutting, and diamond drilling. Undertaken with due care, the district offers a field of real prospective merit" (J. A. Dresser, in **The Canadian Mining and Metallurgical Bulletin**, 1928, p. 341).

There has been renewed activity of late years in prospecting for copper ore in the Eastern townships. In Garthby township there has been considerable sur-

face work done on lot 21, range three. In Wickham township there has been some prospecting on lots 1 and 2, range nine.

PAPINEAU COUNTY

In Petite Nation Seigniory, about 3½ miles north of the nearest point on the north shore line of the Canadian Pacific railway, chalcocite and bornite occur disseminated in Grenville gneiss. The minerals are most abundant in parts of the gneiss that are high in quartz and other parts that are pegmatitic. In a space 25 by 30 feet the copper minerals were seen to be present more or less throughout. The percentage of copper would probably be under one per cent. Similar occurrences are reported on other places along the ridge which marks the locality. A very large body of rock carrying 1½ per cent of copper situated as this prospect is would be a valuable property. (Geological Survey, Ottawa, Summary Report, 1923, Part 6- page 74).

CHIBOUGAMAU

; The Chibougamau area lies around lakes Chibougamau, Doré, David, and Simon, in a country about 120 miles northwest of Lake St. John. A band of anorthosite about 4 miles broad stretches from the northeast end of Lake Chibougamau southwestward across the end of the lake, then across Lakes Doré, David, and Simon Along the northern side of this mass is intrusive granite of two ages, the younger of which is thought to have been the origin of the extensive mineralization seen in all the other intrusive rocks, and in the still older Keewatin volcanics surrounding them.

Throughout this area there are extensive zones of sulphide mineralization, and in places copper pyrites is present in considerable proportions. Thus on the property of the **Chibougamau McKenzie Mining Corporation**, Cedar Bay, Lake Doré, channelled samples taken in a shaft across widths varying from 5 feet 4 inches to 7 feet 6 inches assayed from 0.44 to 8.17% of copper. This ore carries considerable values in gold and small values in silver. The average total value for these three metals across a 15-foot zone was $8.27, of which the copper accounted for $5.23, which would correspond to about 2.2% of copper. With good transportation facilities, large bodies of such ore could be profitably mined.

Chibougamau Prospectors Ltd., have properties on Merrill Island, Lake Doré, and on the mainland opposite the island. On the island is a mineralized zone 35 to 40 feet wide. Assays across a width of 39 feet showed copper averaging nearly 3%, with substantial values in gold and silver. The metallic minerals in this ore body are pyrite, pyrrhotite, and copper pyrites, with quartz and altered anorthosite as gangue. From experience in treating similar ores in other parts of the province, it is probable that the greater part of the gold would go with the copper pyrites in separation by flotation. As the pyrite of this ore body is fairly abundant, up to 50% in places, it would form a by-product of some importance as a source of sulphur.

On the properties of the **Obalski-Chibougamau Mining Company, Ltd.**, on Portage Island, Lake Chibougamau, and on Cache Bay, Lake Doré, occur ore bodies that carry values in copper, as well as in gold. On

the Cache Bay claims there is a vein 2900 feet long. Samples across widths varying from 4 feet 6 inches to 7 feet showed an assay from 0.40 to 6.11% of copper. Gold values were high in the samples that were high in copper. The Portage Island property has a zone of Keewatin volcanics with disseminated copper pyrites. One sample across a width of 6 feet assayed 3.81% of copper.

The properties of the **Chibougamau-Doré Mines Corporation** show large zones of sulphide mineralization, including pyrite, pyrrhotite, and copper pyrites, with some zinc blende and magnetite. One of these zones on Cedar Bay is from 150 to 200 feet wide and more than 2000 feet long. Quartz and calcite are seen, the former in veins up to 10 feet wide. The fine-grained sulphides form a large proportion of the rock, in places as much as 50 to 60%. Both the mineralized rock and the quartz carry values in copper and gold. On the **Sullivan Line Group** is another and still larger shear zone with heavy mineralization of pyrite, pyrrhotite, copper pyrites, and zinc blende. Should sampling and diamond drilling prove these large bodies to carry 2 or 3 per cent of copper, they may be profitably worked.

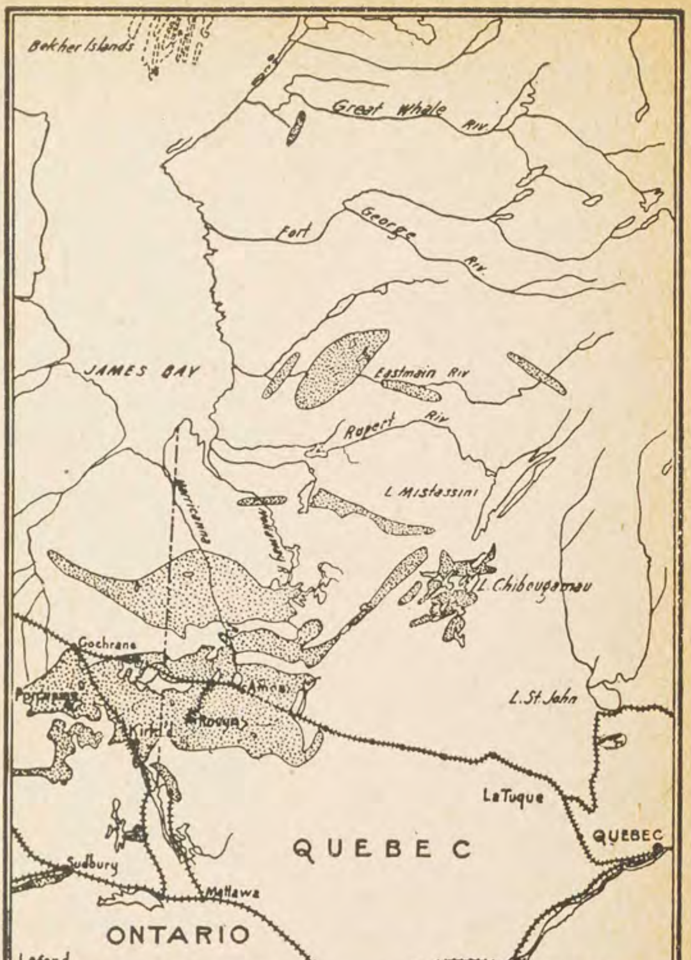
The claims of the **Blake Development Company** on Merrill Island, two miles southwest of the Chibougamau-McKenzie property on Cedar Bay, show rather extensive mineralization that may be developed into copper ore.

On Cedar Bay, Lake Doré, the **Consolidated Mining and Smelting Company** has done a good deal of work on a zone of mineralization that has been sufficiently encouraging to warrant several seasons' work.

GASPE

York River. Copper ore has been found at the head waters of the York River around the origin of the South Branch. The area is about 22 miles south of the north shore of the Gaspé peninsula, and about that distance in a straight line from Mont Louis, the nearest harbor on the St. Lawrence shore. The ore occurs as a contact metamorphic deposit where limestone, probably of Devonian age, is intruded by quartz porphyry. Copper pyrites and pyrite occur in narrow seams with quartz. Some of the veinlets are pure copper pyrites, and this mineral is also disseminated through the rocks.

Matane. Matane is the eastern terminus of the Canada and Gulf Terminal railway which joins the Canadian National at Mont Joli. The rocks are sedimentaries of Ordovician age, including shale, limestone, sandstone, and limestone conglomerate. With these rocks are associated at Gagnon brook basic lava flows which are amygdaloidal in places. A number of years before native copper was found in place, blocks of this basalt were found containing native copper in pieces up to a pound, and a pound and a half, in weight. In 1893 the mineral was found in place on Gagnon brook, St. Denis township. The filling of the amygdules is mostly white calcite and red siderite. There are also veinlets of quartz in the basalt. The native copper occurs mostly in the calcite. Diamond drilling has shown disseminated bornite and chalcopyrite in calcite and limestone over a width of 74 feet. Gold is present in small amount. The amount of ore so far indicated has not warranted further development.



Map showing the extent and distribution of the early Precambrian schist complex.

From *Geological Sketch and Economic Minerals,* Quebec Bureau of Mines.

In Lemieux township, on the Lyall and Beidleman claim 960, there is a mineral zone 50 to 75 feet wide containing small quantities of copper pyrites and tennantite. Copper minerals have been noted on some of the claims of the Pioneer Mining Corporation, on Block E of the New Richmond Mining Company's properties and in other localities in the township, but no deposit of copper ore has so far been discovered.

NORTHWESTERN QUEBEC

Copper ores containing more or less gold have been found at many points in the counties of Abitibi and Témiscamingue, in a region extending eastward from the Ontario boundary to Bell River. Exploration has been carried on most extensively south of the Canadian National railway, but it has also been pushed north of this line. The most important bodies of copper ore have been found in the townships of Rouyn, Duprat, Dufresnoy, and Boischatel. Discoveries made in Desmeloizes and Cléricy townships may prove to be important as copper ore bodies. These copper-gold deposits have been found in Keewatin volcanics north of the band of Timiskamian sedimentaries that crosses the district from west to east. It is probable that they are connected in origin with bodies of granodiorite around which they are grouped. Thus, the Horne, the Waite-Montgomery, and the Amulet ore bodies are not far from the edge of the granodiorite mass that outcrops in many places west of Lake Dufault in Dufresnoy and Duprat townships. It is thought that the smaller masses formerly described as "older gabbro," but now known to be quartz diorite, are identical with

the more basic parts of the larger masses, which are believed to be in the form of sills. One of these sills surrounds Lake Flavrian in Duprat township and extends southward into Boischatel township. There are a good many smaller masses in the country between the important discoveries of copper-gold ore and the Ontario boundary, including Montbray and Hébecourt townships, in both of which copper pyrites has been found in a number of places in mineralized zones. A good deal of work has been done in Montbray township, but no important ore bodies have been developed. Another large granodiorite mass extends through Dufresnoy, Cléricy, and the northern part of Joannes township. Copper pyrites has been found along the edge of this mass, both in a disseminated condition and as small bodies of high-grade ore, but no large ore body has so far been discovered.

There is evidence that the more basic edges of these large granodiorite masses, where hornblende sometimes constitutes 50 per cent of the rock, represent the lower surfaces of sills, and it is significant that the important copper-gold ore bodies are grouped around the basic edge of the Dufault sill, and in such positions as to suggest a close relationship to the under surface of the sill. The ore in these bodies has a basic gangue. On the other hand there are small quartz veins in the much altered Keewatin roof overlying the centre of the Lake Flavrian sill. Some of these quartz veins carry a good deal of copper pyrites. The mineralization in this case came from the upper part of the sill where quartz predominated.

As the evidence so far accumulated points to a close connection between the bodies of copper-gold ore and the intrusions of granodiorite and quartz diorite, the country around masses of these rocks should be carefully prospected.

FABRE TOWNSHIP

This township borders the east shore of Lake Temiskaming near its southern end. In an area of Keewatin green schists, iron formation and quartzite, intruded by porphyries and diabase, there are veins mineralized with considerable proportions of copper pyrites and other sulphides.

OPAZATIKA LAKE

This lake is partly in Boischatel township, with extensions into some of the adjoining townships. Numerous quartz veins in the neighborhood of the lake have attracted attention. They have proved to be barren of gold, but some of them carry considerable proportions of copper pyrites, bornite, pyrite, and zinc blende.

BOISCHATEL TOWNSHIP

Aldermac Mine. This property is in the western part of Boischatel township. The country rocks are Keewatin greenstones cut by dikes of gabbro and red syenite porphyry. The porphyry carries copper pyrites, zinc blende, and magnetite. The ore bodies are in the form of lenses roughly parallel and striking east-west The ore consists of copper pyrites associated with a large proportion of pyrite, and also with pyrrhotite. In places zinc blende, is plentiful. A good deal

of the ore can be concentrated so as to yield pyrite as a by-product. (See **Pyrite,** p. 211). In the upper levels some comparatively small ore bodies average 4.25 to 8.31 per cent of copper and 70 or 80 cents a ton in silver and gold. The total tonnage developed and indicated is very large. Diamond drilling indicates bodies from 60 to 105 feet wide averaging 1.3 to 1.4% copper, with sections of much higher grade. The drilling has gone to depths of 1130 and 1190 feet, the ore at the latter depth being massive sulphides 60 feet wide carrying 1.3% copper. At 1130 feet the drill passed through 4 feet of sulphides averaging 14.55% copper. In No. 4 body at 500 feet, the ore carries 1.75% copper and 1.23% zinc. On the 1125-foot level a body of sulphides with a maximum width of 148 feet has been encountered. It assays 1.98 per cent in copper.

ROUYN TOWNSHIP

Horne Copper Corporation. This company is a subsidiary of Noranda Mines, Limited. The Horne Corporation operates the copper-gold deposits near Osisko (Tremoy) Lake in Rouyn township. These deposits are in Keewatin lavas of acid and intermediate composition, and are confined to a belt 2000 feet wide from north to south where the lavas have been drag-folded. The ore is not found in masses of gabbro that intrude the lavas. The gangue is rhyolite and andesite, and the ore bodies are looked upon as replacements, more or less complete, of these rocks. Where the wall rocks are rhyolite and rhyolite tuff, pyrite has been deposited, but where the wall rocks are andesite the deposit is pyrrhotite and copper pyrites. The copper

pyrites was deposited last, replacing the pyrrhotite There are rich ore bodies carrying 10% or more of copper, and as high as $6 a ton in gold. The average content of the ore as smelted in 1928 was 6.52 per cent of copper, 0.64 ounce of silver, and $3 a ton in gold. The mine is equipped to produce 2000 tons a day.

By diamond drilling, ore bodies have been discovered that do not apear on the surface. In January 1929, the indicated tonnage of ore amounted to 3,097,000 tons, having a gross value of $79,340,000. The average grade of this ore is approximately 7.31% copper and $3.68 a ton in gold.

In 1928 the smelter treated 271,926.1 tons of ore, flux, and concentrates, and produced 33,307,937 pounds of blister copper averaging 99.27% copper, and 11.20 ounces silver and 3.18 ounces gold per ton.

The concentrator is equipped to treat not only copper-gold ores, but also the more complex ores containing zinc. Ore of this character from the Waite-Ackerman-Montgomery mine has been treated at the Horne concentrator.

Claims have been taken up and explored all around the Horne property including the bottom of Osisko Lake, but while small bodies of copper ore and mineralized zones have been reported, no important ore body is known to have been found.

MONTBRAY TOWNSHIP

A good deal of work has been done in this township by Nipissing Mines, Ltd., The Consolidated Mining and Smelting Co., Ltd., and other companies, but, while some small high-grade ore bodies have been

found and wide dissemination of copper minerals has been proved, no important deposits of copper ore have so far been discovered. The results obtained by Nipissing Mines, Ltd., on the Robb-Montbray property in the southeast corner of the township are the most interesting. Three deposits have been explored by trenching, diamond drilling to a depth of 1000 ft., and sinking and drifting, the shaft having been put down to a depth of 525 feet. Small bodies of ore high in gold and copper were encountered, but no deposits sufficiently large to warrant further mining.

DUPRAT TOWNSHIP

Waite-Ackerman-Montgomery Mines, Ltd. This company controls a group of claims partly in Duprat and partly in Dufresnoy township, west of Lake Dufault. The first discovery was made in 1925 by the rather accidental observation of a rusty mass on the roots of a fallen tree. This led to the uncovering of a spectacular showing of solid sulphides assaying high in copper and zinc. The ore minerals are pyrite, copper pyrites, zinc blende, and a little pyrrhotite. This ore assayed 17.3% copper, 3.6% zinc, $0.40 a ton in gold, and 2.8 ounces of silver per ton. The copper pyrites was deposited later than the pyrite and pyrrhotite, replacing the pyrrhotite chiefly and the pyrite only slightly. The character of the wall-rock influences the deposit. Where it is rhyolite, pyrite has been deposited, but pyrrhotite is found between andesite walls. It follows that the best copper ore is to be looked for in the more basic rock. The sulphides replace the country rock more or less completely and are accompanied by

little or no quartz and calcite. Magnetite occurs in places. There is little alteration of the rock outside of the ore bodies. The ore as shipped to the Horne smelter in 1928 averaged 6.187% copper, 3.47% zinc, \$1.74 a ton in gold, and 1.08 ounce of silver per ton. Shipments were being made at the rate of 2000 tons a month.

Coniagas Group. This property is in the southwest corner of Duprat township and partly in Montbray township. A shear zone follows a basic dike and has been traced for a length of about 300 feet. It is mineralized with pyrite, copper pyrites, and zinc blende over widths up to 12 feet. A second mineralized zone about 6 feet wide intersects this.

Bedford Mines, Limited. This property is in the southeast quarter of Duprat township just west of the Amulet. Copper pyrites occurs in fissures on andesite over an area 160 feet by 300 feet.

Chas. M. Heron Group. On a group of claims north of Flavrian Lake, a narrow vein of high grade copper pyrites with quartz is reported.

DUFRESNOY TOWNSHIP

Amulet-Gold Mines, Limited. This company holds claims on both sides of the boundary line between Dufresnoy and Duprat townships, and from one mile to 2½ miles from the south boundary of the townships. The country rocks are Keewatin lava flows, which in the area including the Amulet and Waite-Ackerman-Montgomery properties form the flat top of a great anticline. The lavas are of two kinds, (1) hard, glassy rhyolite, fine-grained, very amygdaloidal and porphy-

ritic; and (2) on this a more basic lava of a peculiar type, 'dalmatianite.'' This rock is dark, brownish black with round whitish nodules up to ¾ inch in diameter. It is highly amydaloidal in the upper part, and shows pillow structure in places. The ore bodies have been formed by the replacement, partial or complete, of the upper part of the dalmatianite by pyrite, pyrrhotite, copper pyrites, and zinc blende. The copper pyrites came last. As ore does not seem to have been deposited in the rhyolite, it follows that the ore bodies will be vertically discontinuous, being repeated in the layers of dalmatianite alternating with those of rhyolite.

The content of the ore varies, the major values being sometimes in copper and sometimes in zinc. For No. 2 ore area, the copper runs pretty evenly from 4% to 5.5%, while the zinc is from 0.4% to 10.5%. The gold values are from $0.40 to $2.75 a ton, while silver ranges from 0.7 to 3 ounces a ton.

Newbec Mines, Limited. Copper ore has been discovered on the claims of this company in Dufresnoy township. Several lenses have been opened up by sinking, drifting and cross-cutting. Ore assaying 8 to 15 per cent copper over mining widths is reported. The claims are near Lake Dufault. These developments are being carried on in a fracture zone at least 2000 feet long.

McDougall Mines, Limited. This company holds a group of claims east of the Amulet. Diamond drilling near No. 2 ore body of the Amulet indicated ore from 200 feet to 300 feet, the ore being reported to average 2.5% copper from the 197th to the 250th foot, the first

12 feet averaging 4.0% copper and $1.25 a ton in gold.

CLERICY TOWNSHIP

A large mass of granitic rock cuts through the southwest part of this township, and there is a good deal of mineralization with copper pyrites and other sulphides in its neighborhood. No large body of copper ore has been developed, but encouraging results have been obtained in several localities.

Archean Mines Development Co., Ltd. The claims of this company are near the western boundary of the township, south of the Kinojevis River. A mineralized zone parallel to the granite contact carries pyrite, copper pyrites, and zinc blende in the interstices of shattered rock. The width of this zone is 20 to 25 feet, half of which is said to be commercial ore. Several other mineralized zones have been found farther north.

HEBECOURT TOWNSHIP

Mineralized zones have been found in this township, which adjoins the Ontario boundary north of Montbray township. Disseminated copper pyrites occurs in a number of places. The Consolidated Mining and Smelting Company has done a good deal of exploration on claims near the centre of the township.

DUPARQUET TOWNSHIP

Silver—Prickett Group. This group of claims is south of Lake Dugros in Duparquet township which lies immediately east of Hébécourt township. A large pyrite body has been found but the copper content is very low (See **Pyrite** p. 211).

DESTOR TOWNSHIP

This township is on the east side of Duparquet township. It is crossed by the government road and by the Rouyn branch of the Canadian National railway. Disseminated copper pyrites occurs in a number of places, including the claims of Destor Mines, Ltd., in the northeast quarter of the township, and Makamic Mines, Inc., in the northwest quarter.

DESMELOIZES TOWNSHIP

This township is north of the Canadian National railway main line at the Ontario interprovincial boundary.

Abana Mines, Limited. This property is near the northern boundary of the township in range ten. It is reached by the colonization road from Dupuy station on the Canadian National railway. There are several ore bodies, one being rich in zinc, and another showing over 10 feet in width of massive copper pyrites with a little zinc. Diamond drilling from the 300-foot level showed an ore body from 3 to 51 feet wide over a length of 200 feet. The value per ton ranges from $9 to $33. This ore body averages 21 feet in width with an average value of $24.30 per ton. The percentages of copper and zinc are about equal. The ore body has been proved to a depth of 500 feet and development is continuing.

LA SARRE TOWNSHIP

This township is crossed by the main line of the Canadian National railway. It lies east of La Reine township, which adjoins the Ontario interprovincial boundary.

Norrington Development Company, Ltd. The property of this company is about 5 miles north of the railway in range nine. It is reached from La Sarre station by road The country rock is volcanic tuff intruded by acid porphyry and granodiorite. Diamond drilling is reported to have cut commercial ore 25 feet wide carrying copper and zinc.

GUYENNE TOWNSHIP

This township is east of La Sarre with two townships between. Mineralized zones have been found in the township. On the Smylie group of claims in range nine a zone of sulphides, mostly pyrrhotite and pyrite with a little copper pyrites, has been uncovered. In ranges eight and nine, the Guyenne Mining Company, Ltd., has opened up a narrow mineralized band containing much pyrite and pyrrhotite with a little copper pyrites. Hornblende schist is the commonest country rock. The claims of Porcupine Crown Mines, Limited are in range nine. A mineralized zone said to be more than 1000 feet long shows galena, zinc blende, and copper pyrites.

DALQUIER TOWNSHIP

Dalquier township is north of the main line of the Canadian National railway. The town of Amos is on its southern boundary| The township is underlain mostly by Keewatin volcanic rocks with intrusions of granite.

Jay Copper-Gold Mines, Limited. The property of this company is in ranges one and two, four miles from Amos. Copper pyrites occurs as high-grade stringers and small lenses in the sericite schist.

GENERAL

In addition to the copper ore deposits, copper minerals occur as minor constituents of zinc-lead and other complex ores (See **Tetreault Zinc Mine** p. 103).

REFERENCES:

Copper in the Eastern Townships, by John A. Dresser, The Canadian Mining and Metallurgical Bulletin, No. 191, March, 1928, p. 341.

Gold and Copper Deposits of Western Quebec, by H. C. Cooke, Geological Survey, Canada, Summary Report, 1925, part C, p. 28.

On the Origin of the Copper Ores of the Rouyn District, by H. C. Cooke, Geological Survey, Canada, Summary Report, 1926, part C, p. 48C.

Report on Mining Operations in the Province of Quebec, 1927.

NICKEL

A description of the principal nickel minerals will be found at pages 6 and 7. While pyrrhotite has been the principal nickel-bearing mineral in Ontario, it is exceptional for pyrrhotite to carry more than a trace of nickel. Most of its occurrences outside of the Sudbury region have proved to be too low in nickel to be of economic importance.

Pentlandite and polydymite are apt to be overlooked when mixed with pyrrhotite and pyrite, but the coppery red color of niccolite and breithauptite makes them conspicuous. When nickel minerals weather, the products are apt to be of a green color of a different

shade from the green of copper stains. The colour may be completely obscured by the iron rust resulting from the weathering of iron sulphides, but the green of **garnierite,** a silicate of nickel and magnesium, or of **annabergite,** arsenate of nickel, may guide to a discovery.

Small quantities of nickel and cobalt occur in pyrite in a quartz vein in Daillebout seigniory, on the River Assumption.

In the Eastern Townships serpentine belt, nickel has been found in veins cutting the magnesian rocks in the townships of Orford, Sutton, Bolton, and Ham, but in small quantities only. In one place, however, about three quarters of a mile east of Brompton Lake, on lot 6, range XII, Orford township, a calcite vein carries millerite, a sulphide of nickel, in such quantities as to have attracted attention a good many years ago. The ore is at a contact of pyroxenite with crystalline limestone. Mining operations were carried on and a smelter was built, but as the ore as a whole carried only about one per cent of nickel the venture was not successful.

Niccolite occurs with smaltite in calcite veins in Fabre township on the east side of Lake Temiscaming, but the quantity found is not important.

COBALT

Cobalt is a constituent of a large number of minerals, and the high price of the metal and its oxide makes it profitable to extract them from a number of ores as chief products or as by-products. The silver

ores of Northeastern Ontario carry considerable percentages of cobalt, principally in the minerals smaltite, chloanthite, and cobaltite. **Smaltite** is composed of cobalt, 28.2 per cent, and arsenic, 71.8 per cent. **Chloanthite** is the corresponding nickel mineral, which however carries more or less cobalt, so that the two minerals grade into each other. **Cobaltite** is composed of cobalt, 35.5 per cent, arsenic, 45.2 per cent, and sulphur 19.3 per cent. More or less of the cobalt is replaced by iron, and the nickel mineral, gersdorffite corresponding to cobaltite, sometimes carries important amounts of cobalt. The same is true of the iron-arsenic-sulphur mineral, **mispickel**, a variety of which **danaite**, carries from 3 to 9 per cent of cobalt. Pyrite sometimes carries cobalt. When the cobalt-arsenic minerals weather they form a pink mineral, **erythrite**, or **cobalt-bloom**, composed of cobalt, arsenic, oxygen, and water. This mineral appears as pink coatings and crusts over smaltite and other cobalt arsenides, and has served as a guide in prospecting for silver veins in Northern Ontario and in a similar territory in Quebec east of Lake Temiskaming. The association of silver with the cobalt minerals, while very general in that district, is not invariable. Veins of smaltite etc., have been found so low in silver as to be useless as silver ore. If the veins are large enough, they can be profitably mined for cobalt and arsenic. Nickel arsenides by weathering form a green mineral, **annabergite**, and when both cobalt and nickel are present in the mineral, the pink of erythrite may be masked by the green of annabergite. The result is often a white or light gray coating. Erythrite coatings and stains may

appear as the result of small and scattered grains of smaltite, etc. It has often been observed in diabase dikes and other situations where the quantity of cobalt minerals was insignificant.

Uses. The metal is used as a constituent of a number of alloys. **Stellite** alloys are made from cobalt and chromium, with the addition of tungsten and sometimes of other metals. One group of alloys has cobalt, 50% to 60%; chromium 40% to 30%; tungsten, 20% to 8% Stellite alloys are used for the manufacture of machine tools, cutlery, surgical and dental instruments, evaporating dishes, annealing dishes, ornamental metal work, valves, plumbing fixtures, pens and combs. The silvery white color, stainlessness, and great hardness (some varieties are harder than quartz) fit it for these uses. Cobalt steels, made by adding small percentages of cobalt to steel have superior properties for the manufacture of permanent magnets, including decrease in the size and weight of the magnets. Some applications of permanent magnets are possible only with cobalt steel magnets. **Cobalt oxides** are used for making the fine permanent blue color, **smalt blue** or **cobalt blue.** This is done by melting the oxide with a kind of glass and grinding the melt to a fine powder. **Cobalt salts** (oleate, etc.) are in growing demand as paint dryers.

Cobalt bloom and smaltite occur in calcite veins in Fabre township on the east side of Lake Temiscaming. The veins are in gabbro, and have been found over a considerable part of the township. Shafts have been sunk on a number of them, but the cobalt minerals have not been found in economic quantities. The smal-

tite is accompanitd by niccolite. A vein on lot 3 north, range V, carries a considerable proportion of silver.

Cobalt minerals have been found in a calcite vein in Duhamel township, lot 5, range VIII, but the quantity is not important.

These occurrences of cobalt and nickel minerals are similar to those of the Ontario silver areas west of Lake Temiskaming.

Cobalt bloom occurs rather plentifully in the cracks of a talc deposit in Broughton township, Beauce county. The quarry is on lot 12, range XI.

CHAPTER V

METALLIC MINERALS (Cont'd)

IRON

Introduction. Only a few of the many iron minerals are used as ores of iron, namely, the oxides and the carbonate. The ore most commonly used is **hematite,** the pure mineral containing 70% of iron with 30% of oxygen. Next in importance is **magnetite,** with 72.5% of iron and 27.5% of oxygen. **Siderite** is carbonate of iron, the pure mineral carrying 48.3% iron. There are complex carbonates of iron, magnesium, etc., such as ankerite, sometimes used as iron ore. **Limonite,** sometimes called **brown hematite,** is hydrated hematite. When it is heated, it loses water, and hematite is left. The pure mineral carries 59.9% of iron. When it is found in a loose condition at the bottoms of bogs or lakes, it is called **bog ore** or **lake ore.** Deposits of this kind are often found beneath the soil in places formerly bogs or lakes but drained by some natural change in the conformation of the surface. There are several varieties of iron ore that in composition come between hematite and limonite.

To be economically useful iron ore must fulfil certain conditions of purity, quantity, and accessibility.

The average percentage of iron in the ore charged into blast furnaces on this continent is about 51%. A certain amount of ore containing less iron than this is sometimes mixed with richer ore, but, in general, ore that carries less than 50% of iron must be concentrated, if it is to be used. The ore must be low in sulphur and phosphorus because these elements impair the quality of iron and steel. While it is possible to eliminate them, the sulphur by preliminary roasting and the phosphorus by a modification of the process of steel-making, these purification processes cost something and so the presence of the impurities decreases the value of the ore. On the contrary, when the iron is to be used for making ordinary castings such as stoves, a certain phosphorus content is sought in the ore, as the resulting pig iron melts more easily, and makes a better casting. The "Bessemer limit" for phosphorus is .01% for every 10% of iron in the ore. For example, if an ore containing 55% of iron carries more than .055% of phosphorus, it is not admissible for making steel by the ordinary Bessemer process. More than a small percentage of titanium in the ore is considered objectionable because of difficulties that have been experienced in smelting high-titanium ore.

Small deposits of iron ore, no matter how good in quality, may be of no economic value, because it would market for small quantities of iron ore, because the not pay to mine them in competition with larger deposits. There is an especial difficulty in getting a users wish to run their furnaces with ore of known quality. When a new source of supply is offered,

it is looked at coldly, even when the quality is good, unless a large annual tonnage can be guaranteed.

Accessibility is a very exacting requirement in the case of iron ore. The price is so low, $5 to $6 a ton delivered at or near the furnaces, that the transportation costs must be correspondingly low.

Classes of Iron Ore Deposits. Iron ore deposits may be divided into classes (1) according to the composition of the iron minerals constituting the ore, or (2) according to the geological nature of the deposits. The first method of classification would give classes under the names, magnetite, hematite, etc. The second divides the ore deposits into the following classes:

1. **Vein-like deposits** of magnetite and hematite, usually as lenses at or near the contact of an igneous intrusion with the intruded rock. Examples of this are some of the magnetite bodies in Hull and Pontiac counties.

2. **Segregation deposits** of magnetite and titaniferous magnetite, found at or near the outer edges of basic intrusives such as diabase and gabbro, and believed to have been derived from these rocks by separation during slow cooling from a liquid condition. Examples, the titaniferous magnetite of the St. Charles area.

3. **Banded Iron Formation.** This consists of alternate bands of magnetite or hematite with chert, jasper or other varieties of silica. Sometimes both magnetite and hematite are present, and occasionally there are bands of siderite and pyrite. The iron minerals are sometimes mixed with the silica and banding may not be visible. The bands of hematite and magnetite are

sometimes very high-grade, but oftener they are mixed with enough silica to make them lean. There are immense quantities of the banded iron formation widespread in the province, but there are no large bodies known that can be classed as merchantable iron ore. Banded iron formation is thought to be of sedimentary origin.

4. **Secondary and Residual Deposits**. Under this head are put bog ore, and other deposits that have been formed either by the leaching out of iron from the rocks and subsequent deposition in a hollow, or by the removal of materials from a mixed deposit so as to leave only the iron ore in place. In both these operations chemical changes of the substances have played a part.

Iron Ore Minerals

Hematite. The common variety of this ore is **red hematite.** All varieties are red when ground to a fine powder. The natural red hematite is fine-grained enough to have the color of the powdered mineral. It is often soft enough to powder with the fingers. When the ore is coarser grained and compact, it is steel-gray in color. When the crystals are still larger and show shining surfaces of a considerable size, it is called **specular ore** or **specular hematite.** When the crystals are small scales that easily separate and shine like mica, this ore is called **micaceous hematite.** Sometimes the ore has been deposited in rounded masses with a certain structure that suggests the name **kidney hematite.** Limonite sometimes has the kidney structure. Hematite is preferred as an iron ore because it is usually more porous than magnetite, allowing the

reducing gases of the furnace to penetrate it more readily. This increases the speed of reduction and thus lowers the cost of smelting.

Magnetite. This ore owes its name to its strong attraction for the magnet, a property possessed only feebly by hematite. It varies in color from dark gray to black. When finely powdered, it is black. On account of its strong magnetic attraction, hidden bodies of magnetite can be detected by the deflection of the compass needle. The **dip needle** is swung on a horizontal axis and when correctly manipulated, it can be used to measure in a relative way, the strength of the attraction. The **magnetometer** is a finer instrument used for the same purpose. It is possible by its use to survey a concealed body of magnetite and determine approximately its extent.

Limonite or **Brown Ore.** This is sometimes found in soft masses, or in cakes or grains, as a surface deposit. It is then called **bog ore**. Such deposits are usually too small to be of importance, but some large ones have been found. The ore has sometimes been altered by heat and then consists partly of dense, hard limonite, partly of hematite, and partly of intermediate minerals, particularly **goethite**, a brown mineral looking a good deal like limonite. Occasionally limonite is found in rounded masses suggesting the shape and structure of a kidney. It is then called **kidney ore** (see also **Hematite** p. 84).

Siderite. Also called **iron spar** and **spathic iron ore.** It is carbonate of iron containing, when not mixed with other minerals, 48.3% of iron. As found in nature, it is mixed with more or less of the carbonates of

lime, magnesia, and manganese. All these are useful constituents of iron ore. The lime and magnesia act as fluxes for the silica present and so help to form the slag. Manganese improves the quality of steel. There are various mixtures of these carbonates with carbonate of iron that receive special names, the commonest being **ankerite.** Siderite, ankerite, and other minerals containing carbonate of iron are apt to show their presence at the surface by the rusty material formed when they are weathered. Some siderite deposits are fine-grained and of a gray color, but others are nearly black. Well-crystallized siderite is like calcite in its cleavage, but is harder and heavier.

IRON ORES IN QUEBEC

Iron ores have been mined and smelted in small blast furnaces at a number of places in the province, but even where the ore was good, the expansion of the iron blast furnace industry and the use of large furnaces made it unprofitable to work on the small scale. In several places the ore used was unsuitable owing to its high titanium or silica content.

For many years, bog iron dredged from Lac à la Tortue, betwenn Three Rivers and Grand'Mére, supplied the furnace at Radnor Forges, where a pig iron of excellent quality was made. Bog ore was taken out at Acton in Bagot county, at St. Wenceslas, in Nicolet county, and at Wickham in Drummondville county, to supply the furnace at Drummondville. Bog ore was also used for many years in the furnaces at L'Islet, Yamaska, and St. Maurice. The deposits, worked many years ago, are mostly exhausted, but many deposits on both sides of the St. Lawrence, and

particularly at the foot of the Laurentian hills on the north side of the river, have not yet been drawn upon. They are not large enough to sustain a modern iron industry.

HULL COUNTY

FORSYTH MINE

This is about 5 miles northwest of the city of Hull. The ore bodies are magnetite with a little hematite in crystalline limestone. The ore runs from 53% to 60% in iron, is low in phosphorus, and sulphur. One estimate based on diamond drilling is 430,000 tons.

Other deposits such as the Baldwin near the Forsyth, and the Haycock in Templeton township, are considered too small to be of economic importance.

PONTIAC COUNTY

BRISTOL MINE

The Bristol Mine is in Bristol township about 4.8 miles northwest of Chats Falls on the Ottawa River. The ore bodies consist of magnetite with some hematite. The ore is interbanded with mica and hornblende schists. Crystalline limestone occurs in the vicinity,. and all these rocks are cut by intrusions of granite. The largest ore lenses are about 40 feet wide. The ore is low in phosphorus, but contains so much pyrite that it is necessary to roast it before smelting. Analysis of average samples show 53.74% to 58.18% iron, 1.48% to 2.90 % sulphur, and 0.007% to 0.008% phosphorus. The tonnage of ore available may be large, but there are not sufficient data available for an estimate.

There are other deposits known in Clarendon, Calumet, Litchfield, and Sheen townships, but so far as known the quantity of ore in them is not large.

OTHER OCCURRENCES OF MAGNETITE AND HEMATITE

Small deposits of magnetite in gneiss and hornblende schist have been known for many years in **Grenville** township, Argenteuil County. Some scattered magnetite and hematite in quartzite has been prospected in **Spalding** township, Compton County. The material carries over 5% of manganese but only 18% of iron. In **Gaspé** County and in Bonaventure County veins of siliceous hematite occur in Ordovician schists, but the quantity is not important. In **Leeds** township, Megantic County, there are small lenses of magnetite in chlorite schist, but the ore bodies are not large enough to be of economic importance.

TITANIFEROUS MAGNETITE

The numerous deposits of titaniferous magnetite found in Quebec occur in gabbro and anorthosite as segregations from those rocks.

BEAUCE COUNTY

Near Beauceville station on the Quebec Central railway, a number of deposits of titaniferous magnetite have been uncovered along a line 3 miles long between the Des Plantes and Caldwell branches of the Chaudiere River.

The workings on the Bloc Range are about 5½ miles from Beauceville station. The titaniferous magnetite occurs in small irregular stringers and pockets in ser-

pentine rock. The quantity is small. The ore in some of the pockets carries chromium and very little titanium.

On the **St. Charles Range,** lots 300 and 301, are some small pockets of titaniferous magnetite and one lens 10 to 12 feet wide.

HULL AND PONTIAC COUNTIES

A number of small deposits of titaniferous magnetite and hematite occur in the townships of Templeton, Hull, Bristol, Clarendon, Litchfield, and Sheen, but none of them seem to be of commercial importance.

LAKE ST. JOHN COUNTY

On **Alma Island** at the outlet of Lake St. John are some small deposits of titaniferous magnetite containing about 53% iron and 12% titanium. The largest outcrop is about 15 by 30 feet.

CHICOUTIMI COUNTY

The **Kenogami deposits** are about 4 miles from Ratiere station on the Quebec and Lake St. John branch of the Canadian National railway. The quantity is too small to be of economic importance.

The **St. Charles deposits** are on the east bank of the Saguenay River about a mile and a half west of St. Charles village, and about 17 miles from the Quebec and Lake St. John railway. The ore occurs in gabbro-anorthosite. The ore has been traced over a length of 700 feet and with a minimum width of 160 feet. Another body is over 300 feet long and 20 feet wide. The estimated tonnage is at least 5,000,000. The ore carries 50.53% iron and 10.55% titanium. It is low

in sulphur but high in phosphorus. It carries a little vanadium.

CHARLEVOIX COUNTY

For an account of the St. Urbain or Baie St. Paul deposits see **Titanium**, p. 141.

SAGUENAY COUNTY

Bay of Seven Islands. On the **Rapides river** within 4 miles of its mouth on Seven Islands bay, there are a number of deposits of titaniferous magnetite in fine-grained gabbro. The **Cran de Fer Falls** deposit is estimated to contain not less than 300,000 to 400,000 tons of ore, probably very much more. This ore assays 50% to 52% iron and 12% to 15% titanium. In other places the so-called ore is gabbro with a large proportion of titaniferous magnetite. About a mile and a half farther up the river are the **Outarde Falls** deposits, showing a great deal of gabbro rich in magnetite, and a small proportion of solid magnetite.

The **Clarke City** deposits are on the Marguerite River on the west side of Bay of Seven Islands. In the quarry there is a 3-foot-band of solid ore assaying 57.84% of iron and 11.34% of titanium. There is a large amount of rock charged heavily with titaniferous magnetite.

ST. MAURICE COUNTY

Grondin Mine. This deposit is about four miles from St. Boniface de Shawinigan on the Canadian National railway line from Montreal to Quebec. The ore is titaniferous magnetite, carrying 41.5% iron and 5.4% titanium. The deposit is in gabbro. The quantity of ore is not large.

TERREBONNE COUNTY

Desgrobois Deposits. These are about 7 miles from St. Agathe on the Montreal-Mont Laurier line of the Canadian Pacific railway. The railway runs within a few hundred feet of the deposits. There are a number of outcrops of titaniferous magnetite in anorthosite. The ore is a good deal mixed with feldspar and pyroxene. It assays about 43% iron and 6.73% titanium. The quantity of ore is apparently small.

MAGNETIC SAND

At a number of points on the north shore of the St. Lawrence River below Quebec there are sands containing more or less magnetite.

BERSIMIS

This point is 200 miles below Quebec city. The amount of magnetic sand is small, and would not yield more than a few thousand tons of concentrates.

MOISIE

Moisie is 330 miles below Quebec city. The beaches east and west of the mouth of Moisie River are covered with magnetic sand, estimated to be capable of yielding 20,000 tons of pure magnetite.

In addition there are considerable areas of grassy dunes where the sand averages not more than 5% of magnetite. Farther inland are still poorer sands averaging less than one per cent of magnetite.

MINGAN

At Mingan, 430 miles below Quebec city, there are magnetic sands capable of yielding a few thousand tons of magnetite.

NATASHKWAN

The mouth of Natashkwan River is on the north shore of the Gulf of St. Lawrence, about 530 mlies below Quebec city. There are large deposits of magnetic sands in this region. The principal deposts are between the mouth of Natashkwan River and Mont Joli 3 miles eastward. They are found in an area of grassy dunes averaging about 500 feet in width and 15 feet in depth. The sand carries 8 to 9 per cent of magnetite. It is estimated that this area would yield 500,000 tons of concentrates assaying 67% of iron. The magnetite sands are mixed with a small proportion of ilmenite.

DEPOSITS OF IRON ORE IN UNGAVA

LONG ISLAND

Long Island is about 12 miles north of Cape Jones at the entrance of James Bay. There are deposits of low-grade siliceous iron ore similar to those on Nastapoka islands.

BELCHER ISLANDS

The North Belcher islands are about 120 miles north of Cape Jones and about 90 miles west of the Ungava coast line. These islands, Long Island, the Nastapoka and Hopewell groups, and the southern shores of Richmond Golf are underlain by rocks of late Precambrian age, including banded iron formation, recalling the Animikie iron formation so extensively developed in Ontario. On the Belcher islands the iron formation is in part overlain by basalt. It consists of bands of siliceous hematite and magnetite alterna-

ting with bands of silica. Some of the iron ore is high grade, but most of it is highly siliceous, low-grade ore. There may be in some places important masses of merchantable ore, but experience with this formation makes it probable that concentration will be necessary.

RICHMOND GULF

This gulf is almost east of the Belcher islands. Along its southern shores is a band of late Precambrian rocks including banded iron formation. The same formation occurs on islands that fringe the shore.

NASTAPOKA ISLANDS

North of Richmond Gulf is a large group of islands the rocks of which are late Precambrian, including dolomite, sandstone, shale, chert, and banded iron formation. Between the beds are layers of trap rock. The iron formation includes beds of ankerite, hematite, and magnetite, more or less mixed and banded with silica. The better grades carry 30 to 40% of iron. The ore is low in sulphur and phosphorus. The high percentage of silica would necessitate some method of concentration.

HOPEWELL ISLANDS

These islands are north of the Nastapoka group, and show similar iron ore deposits.

PAYNE RIVER

Iron ore occurs near Kyak Bay north of the mouth of Payne River on the west coast of Ungava Bay.

KOKSOAK RIVER

This is a large river emptying into Ungava Bay at its head. In its upper reaches it follows a broad band of late Precambrian rocks which extends southward to the headwaters of the Hamilton River a total distance of about 300 miles. At a number of places iron formation is extensively developed along both these rivers. On a ten mile stretch of the Koksoak River the amount of ore in sight is estimated at hundreds of millions of tons, and a considerable proportion of it is high grade. The ore is jaspery magnetite and hematite, with some bands of siderite and ankerite.

Large blocks of jaspilyte, a mixture of jasper and hematite are frequent on the banks of the Larch River, a branch of the Koksoak coming in from the west. Some of the blocks are nearly solid hematite.

References: **Iron Ore Occurrences of Canada** by E. Lindeman, L.L. Bolton, and A.H.A. Robinson, publication No. 217, Mines Branch, Ottawa.

Preliminary Report on some Iron Deposits on the North Shore of the River and Gulf of St. Lawrence, by Prof. E. Dulieux, in **Report of Mining Operations** in the Province of Quebec during the year 1911, p. 71.

CHAPTER VI

METALLIC MINERALS (Cont'd)

LEAD, ZINC, CADMIUM

LEAD

Introduction. The principal ore of lead is **galena**, the sulphide. It is very much the same in color as bright lead, but when very fine-grained, it is much darker. Galena is quite soft, which distinguishes it from some varieties of specular hematite that may be mistaken for it. When finely powdered, galena is gray, while hematite is brownish red. Galena is among the heaviest of minerals, having a specific gravity of 7.5. The pure mineral contains 86.6% of lead. When this fact is considered along with the high specific gravity of the mineral, it is seen that a relatively small bulk of galena scattered through gangue will give the minimum of 5 to 7% of lead necessary for profitable extraction.

In addition to galena, the carbonate of lead, **cerussite**, and the sulphate, **anglesite**, are sometimes found in sufficient quantities to be of economical importance but as these minerals are usually products of the weathering of galena, they are not likely to occur in quantity in a glaciated country like Quebec.

Galena occurs with other metallic minerals in veins and similar deposits in various kinds of rocks, but deposits of galena workable for lead alone are the exception. The lead mineral is usually accompanied by zinc blende, and often by pyrite, copper pyrites, etc. A great deal of the lead of commerce is produced from these complex ores along with other valuable constituents. Ores formerly rejected because of the difficulty of separating the lead, zinc, copper, etc., are now treated by oil flotation and modern smelting processes, so as to recover all the valuable constituents.

Galena carries more or less silver, and when the quantity is as much as 10 or 15 ounces a ton or more, the ore is called **silver-lead** or **argentiferous galena.** In complex lead-zinc-copper ores, the smelters pay for as low as 2 ounces of silver per ton. Some deposits of galena are very high in silver, and the silver value may be so great as to make the ore essentially a silver ore. A discovery of galena, even if the deposit is a small one, should be assayed for silver.

When the lead ore is accompanied by little or no zinc or copper ore, it is very easily smelted, and the required equipment is comparatively simple. When the ore is more complex, the necessary equipment for reducing it is correspondingly extensive. For this reason, a small deposit of complex ore may not be profitably workable, when it would pay to work a simple galena deposit of the same size.

Kinds of Deposits. The composition of a galena deposit is influenced not only by the rock in which it is placed, but by the natural process which has ef-

fected the concentration of the mineral. If the galena has been deposited in limestone with calcite, fluorspar, and barite, it is less likely to be accompanied by other ores than if deposited with quartz in association with an intrusion of igneous rock. It is usual to distinguish two main classes of deposits:

1. Those due to the after effects of igneous intrusions.
2. Those not obviously connected with igneous intrusions.

Those of the second class may have been caused by igneous intrusions, but the deposition has taken place so far away from the hot mass as to permit of a natural sorting that has left the galena to be deposited pretty much by itself. The deposits of the first class are more likely to carry silver than those of the second.

LEAD IN QUEBEC

Galena accompanies zinc blende in the great majority of deposits of these minerals. (See **Zinc** pp. 100, 103, 104, and 106). The production of lead in Quebec so far has been almost altogether from the zinc-lead deposits in Portneuf county; but lead has been the main product of the Wright Mine on the east of Lake Temiskaming.

Temiskamingue County

Wright Mine. This deposit of galena has been known for at least two centuries. On a map dated 1744, the place is marked **Ance à la Mine.** It is in Duhamel township on the east shore of Lake Temiskaming. The

country rock is conglomerate, and the ore body is roughly cylindrical in shape, — rather a puzzle. The ore is galena carrying about 18 ounces of silver per ton. Pyrite is present, sometimes in considerable proportion. The ore body has been mined to a depth of over 250 feet.

Poirier Lake. This lake is 20 miles south of the Canadian National railway and 50 miles east of the Ontario boundary. Near it is a calcite-quartz vein 4 feet wide, with galena, zinc blende, pyrite, and very little copper pyrites. Silver values are low, and gold is absent. The vein is too small to be commercially important.

Hull County

In Hull township, north of Ottawa, are a number of small veins of galena in a barite-fluorspar gangue. They occur in crystalline limestone. One of these on lot 10, concession ten, is $3\frac{1}{2}$ to $4\frac{1}{2}$ feet wide, and has been traced for more than 300 feet. While these veins are not commercially important, their presence shows the possibilities of finding larger deposits in that area.

Papineau County

In Buckingham township, a number of veins have been found carrying galena in a gangue of barite. These veins occur in crystalline limestone. They are too small to be of economic importance. Larger veins may be found in the same area. (See **Barite**. p. 277).

Petite Nation River

Near this river, a branch of the Ottawa east of Ottawa city, are several small calcite veins carrying

galena and purple fluorspar. These veins are not important in themselves, but they indicate the possibility of workable galena deposits in that area.

Beauce County

At the rapids of the Chaudière River, there is a small quartz vein with galena, zinc blende, mispickel, pyrite, and pyrrhotite. The galena carries about 30 ounces of silver per ton. (See **Silver** p. 54).

Baie St. Paul

This locality is 40 miles below Cap Tourmente on the north shore of the St. Lawrence River. There are a number of calcite veins with galena and green fluorspar. The veins are up to 3 feet in width, and in places there are several parallel veins in a zone. The country rocks are crystalline limestone and gneiss.

Gaspé Peninsula

Some of the veins in the Mount Albert area (See **Zinc**, p. 106) carry considerable proportions of galena, and further development may show that some of the deposits are lead ore rather than zinc ore.

At the east end of the Gaspé Peninsula there is a calcite breccia vein 12 feet wide between sandstone and limestone. The calcite carries a small proportion of galena, but the quantity is not important.

At Little Gaspé Cove there are narrow veins of calcite with galena in limestone. One vein about 18 inches wide carries galena, zinc blende, and copper pyrites. In this place there are several small parallel

veins forming a zone. There are small galena veins in several other places in the vicinity.

Lake Mistassini

In a flat-lying limestone near Lake Mistassini there are masses of galena with some zinc blende. This limestone may be of Animikie age. It has no fossils.

Ungava

At Little Whale River on the East coast of Hudson Bay, galena occurs in limestone. The ore carries from 5 to 12 ounces of silver per ton. Some ore was taken out a number of years ago by the Hudson Bay Company. The same formation extends northward to Richmond Gulf, a distance of 12 miles.

Galena has also been reported south of Fort George on the east coast of James Bay.

References: Report of Ontario Bureau of Mines, 1916, Vol. XXV, Part 2. Some Lead and Zinc Ore Deposits of Eastern Canada, by W. L. Uglow.

Various reports of the Geological Survey of Canada.

ZINC

The common association of lead ore and zinc ore has made it necessary to refer frequently to zinc blende in describing deposits of lead ore. These descriptions are not repeated here; but as there are a number of deposits in which zinc blende is the chief mineral they are described under the head of zinc.

The chief zinc ore mineral is **zinc blende** or **sphalerite** composed of zinc, 67%, and sulphur, 33%. It is usually of a brown to black color, and the black va-

riety is often called **black jack**. The darker varieties contain more or less iron, and the black mineral containing 10% or more of iron is often called **marmatite.** The yellow variety may contain little or no iron, and it is valued as raw material for the manufacture of **zinc white,** an oxide of zinc. Black jack may carry gold and silver, and it sometimes contains mercury. Zinc blende may also carry a small percentage of the rare metal cadmium. Unlike most of the metal ores, zinc blende is a poor conductor of electricity, and so does not respond to methods of exploration that depend upon the conductivity of the minerals sought Other zinc minerals are the carbonate, **smithsonite**, a hydrated silicate, **calamine,** the oxide, **zincite,** and **gahnite,** a compound of zinc oxide with aluminum oxide.

ZINC IN QUEBEC

There are three types of deposits in the province of Quebec that carry values in zinc, (1) Those closely associated with crystalline limestone of the Grenville series, as in Montauban township, Portneuf County. In these, zinc is the chief metal constituent. (2) Quartz veins associated with intrusions of syenite, as in Lemieux township, Gaspé. In these deposits, very pure zinc blende occurs sometimes accompanied by only small amounts of other metallic minerals, but in other places with snbstantial proportions of galena. (3) Zinc blende occurs as a minor constituent in many of the copper-gold ores of Northwestern Quebec, and in some deposits it is the chief metallic constituent. In places the zinc ore is in a body by itself in or adjoin-

ing the copper ore, so that the two can be mined separately. Oftener, they are so mixed as to require separation by selective flotation. These complex ore deposits occur in Keewatin volcanics. (See **Copper**, pp. 68, 69, and 70).

Portneuf County

Portneuf county is about 50 miles west of Quebec city. The county extends from the north shore of the St. Lawrence River northward. About 15 miles from the river it is crossed by a band of Paleozoic rocks, chiefly Trenton limestone. North of this is an area of the Grenville series, including quartzite, gneiss, schists, and crystalline limestone. At places in these rocks there are mineralized zones with pyrrhotite, zinc blende, galena, and copper pyrites. Just at the northern borderline between the band of Paleozoic rocks and the Grenville series, at the Tetreault Mine, the mineralization forms a deposit consisting mostly of zinc blende, with minor amounts of galena, copper pyrites, pyrite and pyrrhotite. At other places pyrrhotite is the main or even the only obvious metallic constituent. The Tetreault deposit is the only one so far brought to production. As there is a considerable area of the Grenville series in Portneuf and adjoining counties, careful prospecting may lead to the discovery of other workable ore bodies.

Tetreault Zinc Mine. This mine is in the township of Montauban, Portneuf county, 6 miles by road southwest of Notre-Dame-des-Anges station on the Montreal-Chicoutimi line of the Canadian National railway. The ore occurs in impure crystalline limestone, a good

deal of which has been changed to tremolite and other secondary minerals. This limestone .has been traced on the surface for a length of over 3000 feet. The other rocks are quartzite and gneiss, and there are intrusions of granite and amphibolite. The granite is largely pegmatitic.

The ore is confined to the limestone. It is fairly constant along the footwall, as gash veins and small lenses that pinch out and scatter towards the hanging wall. The ore is an intimate mixture of zinc blende, galena, pyrrhotite and pyrite, with a little copper pyrites. The zinc and lead in the ore are in the ratio of about 3 to 1. Native silver and a native silver-gold alloy have been observed. The production is 450 to 500 tons a day, the ore assaying approximately 9 per cent zinc, 3 per cent lead, 0.1 per cent copper, 0.09 ounce of gold, and 8.3 ounces of silver to the ton.

The mine is at present owned by The British Metal Corporation. Previous to this ownership some 250,000 tons of ore had been taken out. The present owners mined 285,283 tons between February 1925 and December 31st, 1927. The production of zinc in 1928 was valued at $1,267,876.

St. Lawrence Metals. The property of this company is in Montauban township, Portneuf county, about 5 miles from Notre-Dame-des-Anges station on the Canadian National railway. The mineralization is on the same strike as that of the adjoining Tetreault Mine. Electrical surveying has indicated the extension of the Tetreault mineralization across the British Metals

property for about 1500 feet. A second parallel conductor was indicated about 900 feet to the west.

Calumet Island

This island is in the Ottawa River about 50 miles west of Ottawa city. The nearest railway station is Campbell Bay on the Ottawa-Waltham branch of the Canadian Pacific railway. The rocks are sericitic quartzite, gneiss of sedimentary origin, and crystalline limestone. These rocks are much like those of the Montauban area, but are more folded and schisted. Within a few miles are large areas of crystalline limestone intruded by gabbro and granite. Ore minerals are usually a fine-grained mixture of zinc blende and galena, but in places the two minerals are in separate masses. The galena carries silver. Native silver has been noticed. Pyrite occurs, sometimes plentifully, and small amounts of pyrrhotite, copper pyrites and magnetite are seen. The gangue is mostly country rock, with quartz, calcite, pyroxene, etc. Garnets are absent. The ore is in a series of gash veins and lenses along the footwall, fading out towards the hanging wall. (See **Tetreault-Zinc Mine,** p. 102). The ore minerals also occur as disseminations in the quartzite, gneiss, and crystalline limestone. There are two zones of mineralization a few hundred feet apart. Mineralized portions are separated along the strike by barren parts. The same phenomenon is observed in depth. The greatest width is said to be 20 feet. An assay of a sample representing the dumps gave zinc, 29.19 per cent, lead, 13.75 per cent, copper, 3.17 per cent.

Other similar deposits are reported in the same area, and as bands of crystalline limestone are frequent throughout the region north of the St. Lawrence between Quebec and Ottawa, doubtless other workable deposits of zinc ore will be found.

Gatineau District

Bouchette Deposit. This deposit is 70 miles north of Ottawa, and a mile and a half east of the Maniwaki branch of the Canadian Pacific railway. There is a mineralized zone 3000 feet long at a contact of crystalline limestone and sedimentary gneiss. Zinc blende and copper pyrites in places are in sufficient quantity to make the deposit of ore grade. More surface development is required to show the dimensions of the ore bodies.

Gaspé Peninsula

The Gaspé Peninsula lies between Bay Chaleur and the River St. Lawrence. The central part of the peninsula is occupied by a high plateau, the Shickshock Mountains, which reach heights up to 4200 feet above sea level. From this watershed numerous streams flow north to the St. Lawrence and south to Bay Chaleur. The Dartmouth, York, and St. John rivers take an easterly direction to Gaspé Bay at the end of the peninsula. The plateau has escaped the severe glaciation characteristic of the regions north of the St. Lawrence, and as a consequence most of the surface is covered with a deep mantle of rock débris that makes prospecting very difficult. On the other hand when mineral "float" is found, it can be taken for granted that it has not travelled far. Prospectors in this region

make their finds mostly by tracing the float back upstream or uphill.

Deposits of zinc ore have been found in the Mount Albert area, at the head-waters of the Grand Cascapedia River. This area is mostly south of the Shickshock Mountains, and has elevations of 1800 to 2800 feet. The underlying rocks are Silurian and Devonian limestone, shales, and sandstone with many small intrusions of syenite and porphyry, offshoots of the great granite batholith that forms Tabletop mountain, the east end of the Shickshock range.

A belt of zinc-lead ore deposits has been explored and developed in an area drained by the Brandy and Berry Mountain brooks, underlain by limestone, shale and sandstone of Devonian age. In places volcanic flows come between the sandstone and the underlying sedimentary rocks. The limestone-shale series is intruded by many masses of syenite and porphyry, and by far the greater number of mineral deposits have been found in close association with these intrusive masses. The deposits are in the form of veins with quartz and calcite as gangue, or sometimes as breccia zones. Zinc blende and galena are the ore minerals, with copper pyrites in small proportions. Pyrite and marcasite are also present in small amounts. The zinc blende is of a honey-yellow color and contains practically no iron. As it can sometimes be mined in a very pure condition, the ore is an unusually pure zinc ore suitable for making zinc white. The ores carry gold values from $0.40 to $1.80 per ton. The silver values are low, not exceeding a few ounces a ton.

The area can be reached from Cascapedia on the Quebec Oriental railway, by a good road 46 miles long.

Federal Zinc and Lead Company, Limited. The property of this company has been under development since 1912. The same company has operated claims owned by Lyall and Beidelman, and has a royalty contract on the holdings of the New Richmond Company. The Federal or No. 1 vein is 600 feet long and has an average width of 8 feet. In places it is considerably wider and is locally bordered by mineralized breccia. The shaft is down 257 feet and a good deal of underground work has been done. An average sample of the whole vein so far as exposed gave 7.9 per cent zinc, and 3.8 per cent lead.

The Lyall and Beidelman property has been prospected since 1925 and some promising discoveries have been made. A number of veins have been uncovered, one of which, the "big vein," varies in width, up to at least 30 feet. It has been traced for about 1000 feet. There are good shoots of zinc blende and galena in this vein. Other promising discoveries have been made on these claims, one of which is from 12 to 35 feet wide and has been traced for more than 1000 feet. It is a quartz vein with large masses of galena and some zinc blende.

Pioneer Mining Corporation. The main holdings of this company adjoin those of Lyall and Beidelman on the west of the latter. The most important discovery on these claims is a mineralized zone averaging 32 feet in width, and having a maximum width of 100 feet. It has been traced for over 2300 feet in length. The deep overburden on the flat plateau surface where

the vein occurs has made exploration very difficult. Trenches show chambered quartz, and masses of galena and copper pyrites, but the zinc blend, if present in the original vein matter, has been completely weathered away. Shafts sunk 73 and 39 feet respectively failed to reach solid vein matter. A tunnel driven into the hillside below this big vein intersected several smaller veins including one showing 18 inches of solid galena in an oxidised zone. The oxidised part may represent zinc blende. In the eastern part of this block of claims, a number of discoveries were made, the veins carrying zinc blende and galena, and some of them considerable quantities of copper pyrites.

North American Mining Company. The comparatively small amount of exploration work done on the claims of this company, adjoining those of the Federal Zinc Company, has shown up several veins, one of which is 22 feet wide with quartz and breccia carrying zinc blende and galena. In another place an eight foot quartz vein shows good values in zinc blende.

Gaspé Mines, Limited. On this property, a number of promising discoveries were made in 1927. One vein is about 12 feet wide and has been traced for more than 300 feet. It shows good zinc and lead values. Another mineralized quartz vein has been traced for 600 feet. Its width varies from 7 to 20 feet. Other veins have been exposed, but further work is required to show their value.

General

Enough work has been done in this interesting region to show that it is well worth wider exploration

and a bold policy of development. Finds of zinc and lead ore have been reported from the north side of the Shickshock Mountains. Over the whole region the prevailing mantle of residual soil and rock débris makes prospecting difficult and slow. The float usually found is galena, but this is not to be interpreted as indicating the greater prevalence of that mineral as compared with zinc blende in the original deposits. Zinc blende weathers so much more easily than galena, that large proportions may be present in the vein matter without showing any trace in the float. The occurrence of considerable quantities of solid zinc blende in some of the ore shoots of the Federal property indicates what may be expected.

References: Report of Ontario Bureau of Mines, 1916, Vol. XXV, Part 2. Some Lead and Zinc Ore Deposits of Eastern Canada, by W. L. Uglow.

Recent Developments in Gaspé Peninsula, by F. J. Alcock, The Canadian Mining and Metallurgical Bulletin, No. 191, March, 1928, p. 367.

CADMIUM

Cadmium is a rare metal found only in small quantities in ores of zinc, lead, and copper, and occasionally as the mineral **greenockite,** sulphide of cadmium. This mineral is of a bright yellow color, and is sometimes noticed as stain and coatings on zinc ores. The chief source of cadmium is the flue dust of zinc, lead, and copper smelters. Analyses of zinc blende have not so far shown as much as 5% of cadmium. In the purification of zinc by distillation of the metal, cadmium, having a lower boiling point than zinc, distils

with the first portions of zinc and the two metals oxidise and form a dust, which is used as a source of cadmium.

Cadmium is a soft metal of about the color of steel. Its uses are in making anti-friction and other alloys. Its most important use is in alloying to the extent of one per cent with copper to be used in making trolley wire. It increases the resistance of the copper to wear. The demand for cadmium is increasing.

When zinc refineries are in operation in Quebec, cadmium will probably be a by-product.

CHAPTER VII

METALLIC MINERALS (Cont'd)

STEEL ALLOY METALS

CHROMIUM

Chromite, the only ore of chromium, is a black mineral usually found in serpentine, but also occurring in peridotite and other basic igneous rocks. Other favourable places are the edges of basic intrusions such as norite and gabbro. Valuable chromite deposits have been found in such situations in other countries.

Chromite is composed of chromium, iron, and oxygen. It is used to make ferro-chromium for the manufacture of chromium steel and stainless steel. Pure chromium is extracted from chromite and alloyed with cobalt and other metals to make the **stellite** alloys. **Nichrome** is an alloy of nickel and chromium. Pure chromium is used for electroplating certain parts of machinery.

The greater part of the chromite mined is used in the manufacture of refractory linings for furnaces, and for making a number of chemicals, some of which are the basis for yellow, orange and other paints.

To be merchantable, chromite should contain not less than 50 per cent of chromic oxide. The pure mineral contains 68 per cent. Lean ores can sometimes be profitably concentrated. The deposits are mostly in the form of bunches and veins scattered in the serpentine.

CHROMIUM IN QUEBEC

EASTERN TOWNSHIPS

Chromite occurs associated with asbestos in the serpentine belt of the Eastern Townships, but workable deposits have been found only in the serpentine of the Thetford type. The principal output has been from the district between Thetford Mines and D'Israeli. There are important deposits in the townships of Bolton, Orford, Melbourne, Ham, Ireland, Leeds, Wolfestown, Coleraine, and Thetford.

The first recorded discovery, reported in 1847, was made on lot 26, range seven, Bolton township, described as a vein one foot wide. In 1861, about ten tons of ore was taken out near Lake Nicolet, South Ham Township, Wolfe County, and sent to London and Glasgow. In 1884, chromite was discovered near Black Lake, and thereafter Coleraine township became the scene of much activity in mining and concentrating the ore.

The chromite is found in irregular or lens-shaped bodies of workable size, and also in nodules and grains disseminated through the serpentine and pyroxenite. The gangue minerals are olivine, pyroxene, and serpentine. Magnetite occurs scattered through the rock and sometimes in larger masses. The solid chromite

grades into lean ore, and then into serpentine with chromite scattered through it. One of the largest ore bodies at Black Lake was 80 feet long, from 5 to 50 feet wide, and at least several hundred feet deep. The distribution of the lenses is irregular, but they seem to occur most frequently in a zone parallel to the contact with the sedimentary rocks, and not very far from the contact.

As with asbestos mining, the method mostly used in taking out the chrome ore has been by open cut. A good deal of the ore taken out has been rich enough (from 45 to 55 per cent of chromium oxide) to ship without concentration. Ore ranging between 45 per cent and 10 per cent chromium oxide has been concentrated. The concentration has presented some difficulties, in particular a considerable loss as "fines."

The Quebec chrome district has the advantage of good transportation, not found in most of the countries producing this mineral. There are very large quantities of ore of a somewhat lower grade than the market accepts at present. If the requirements become less exacting, or if prices permit concentration of the leaner ores, these large deposits will be available. Since 1924, there has been no production of chromite in Quebec.

GASPE

There is a small area of serpentine at Mount Albert near the headwaters of Ste. Anne River, and another at Mount Serpentine near Dartmouth River. Chromite has been observed in this serpentine, in small veins. Pieces of float weighing as much as 20 pounds has been found.

References:

Chrome Iron Ore Deposits, by Fritz Cirkel, Mines Branch, Canada, publication No. 29.

Preliminary Report on the Serpentine and Associated Rocks of Southern Quebec, by John A. Dresser, Geological Survey, Canada, Memoir No. 22.

MANGANESE

Manganese is a metal somewhat like iron. It has not been used by itself, but in alloys with iron and other metals. Its chief use is as a constituent of ordinary steel, up to 1%, and alloy steels. Hadfield steel contains 12% to 15% of manganese.

The ores of manganese are as follows:

Pyrolusite, a black oxide of manganese, containing when pure 63.2% of the metal.

Psilomelane, or hard manganese ore, of variable composition. It often accompanies pyrolusite.

Wad or **bog manganese** is a brown, soft, earthy mineral, variable in composition. It looks like bog iron ore, but is darker in color. It sometimes accompanies pyrolusite.

Asbolite is a variety of wad carrying cobalt.

Rhodochrosite is carbonate of manganese. It is a pink mineral, like calcite in general appearance.

Pyrolusite and psilomelane deposits of economic importance are found mostly in limestone, sandstone, and shale of the later geological periods. They sometimes occur in chert, jasper, and quartzite. The chances of finding such deposits in the Precambrian rocks of Quebec are not very good.

Pyrolusite and manganite occur in veins on Amherst Island, one of the Magdalen islands, but so far as known, the quantity is not important.

Wad or bog manganese has been found at a number of places, but the deposits are mostly small, and the mineral is mixed with a good deal of foreign matter, making the quality poor. In Bolton township, lot 20, range XII, there is a bed of wad from 3 to 6 inches deep and covering several hundred square yards. The ore assays 26% manganese dioxide. In Stanstead township, on lot 9, range X, is a deposit covering about 20 acres and up to 10 or 12 inches deep It assays 37% manganese dioxide. Other similar deposits have been observed on the road between Lambton and St. Francis, Beauce Co., on the west side of the Chaudière River, opposite the mouth of the Famine River, and in the seigniories of Ste. Mary and Ste. Anne de la Pocatière. Small deposits occur in the village of La Plaine, Cacouna, and on the St. Louis road about four miles from Quebec city. Other localities are Cleveland township, lot 16, range XIII; St. Sylvestre, lot 9, range St. Charles; Gaspé seigniory, half a mile west of St. Apollinaire church; and near the line between St. Antoine and Lauzon, about two miles south of the St. Lawrence.

On some of the islands of the Nastapoka group along the east coast of Hudson Bay, there are bands of siderite about 20 feet thick and of great extent. Some of this ore caries about 12% of manganese with about 25% of iron.

Reference: Geological Survey of Canada, Annual Report 1888-89, page 113K.

MOLYBDENUM

Introduction. The principal ore of molybdenum is **molybdenite,** a sulphide of the metal. A second mineral, **wulfenite,** a molybdate of lead, has been used as an ore of molybdenum, but it does not often occur in commercial quantities. In parts of Quebec where both molybenite and lead ore are found, there may be localities where the conditions for wulfenite deposits are present. The weathering of molybdenite forms a yellow product, **molybdite** or **molybdenum ochre,** and sometimes a gray mineral, **powellite,** molybdate of lime. Neither mineral is of any importance as ore.

Types of Deposits

Four types of molybdenite deposits are described:

(1) Segregations of pyrite, pyrrhotite, fluorspar, quartz, and feldspar, with molybdenite, in syenite.

(2) Veins of pyrite, pyrrhotite, and quartz in granite-gneiss.

(3) Pegmatite dikes and feldspar-quartz veins.

(4) Contact metamorphic deposits.

Something like 75% of the known occurrences of molybdenite are in acid igneous rocks such as granite, pegmatite, and syenite. It is rarely found except in association with intrusions of igneous rocks.

Depth of Deposits

There is an impression that the molybdenite diminishes at depth, but the evidence for this is by no means conclusive. The workings are mostly shallow, and on account of the irregular and scattered deposition of

the mineral, diamond drilling, unless systematic and close-spaced, does not give conclusive evidence. The fissure-vein type of deposit is apt to persist with depth. At the Marble Bay copper mine, Texada Island, B. C., molybdenite was mined at a depth of 1000 feet.

Reduction

Molybdenum is made from molybdenite by reduction in the electric furnace, either directly or after oxidation. Its fusion point is 2500° centigrade, 745 degrees above that of platinum. It is very hard and commonly brittle, but a ductile variety is made. Its tensile strength when drawn into wires is about half that of tungsten wire.

Uses

For many years molybdenum has been used for making alloy steels. For this purpose ferro-molybdenum is first made by reducing molybdenum oxide with iron in an electric furnace. The Tivani Steel Company, Belleville, reduced the molybdenite directly, the concentrates being charged into the furnace with lime and coke. Ferro-molybdenum contains from 50 to 80% of molybdenum.

Molybdenum steel is made by adding either ferro-molybdenum or calcium molybdate to the melted steel. For high-speed tools, permanent magnets, self-hardening steel, rustless steel, stainless steel, etc., over 1% of molybdenum is used, the percentage for various purposes ranging from 1 to 10. For structural steel the percentage of molybdenum is less than 1%, and is usually 0.25%. Increasing quantities of this low-

molybdenum steel are used in the manufacture of automobiles. It is also used for pressed metal parts, railway forgings and track bolts, armor plate, air flasks, pneumatic hammers, agricultural implements, shovels, machinery forgings, piston rods, chains, pierced tubes, rolls, etc. In the manufacture of low-molybdenum steels, other metals such as nickel, chromium, and vanadium are added as well as molybdenum.

Molybdenum is a constituent of a number of useful alloys containing no iron (non-ferrous alloys), such as **stellite,** the main constituents of which are chromium and cobalt, **chrome-molybdenum,** etc.

In addition to these large uses, molybdenum is used for a number of purposes for which the pure metal is required, including lamp filament supports, winding for electric resistance furnaces, contact making and breaking devices, spark plug points, X-ray apparatus, voltage rectifiers, thermocouples, arc lamp electrodes, plates used in wireless telegraphy, and in dentistry and jewelry. For some of these purposes it takes the place of the much more expensive metal, platinum. A considerable quantity of molybdenite is required for the manufacture of a number of molybdenum chemicals used in chemical analysis, fire-proofing of fabrics, disinfectants, coloring of pottery, dyeing of cloth, silk, wool, leather, rubber, etc., and for a number of other purposes.

MOLYBDENUM IN QUEBEC

Quebec has been the largest Canadian producer of molybdenite, the production being principally from the Moss Mine, at Quyon in Onslow township. Four

types of deposits are represented in the Quebec molybdenite occurrences (See also page 116).

(1) Molybdenite associated with pyrite, pyrrhotite, and fluorspar, scattered through masses of pegmatitic granite and syenite. The Moss mine is an example of this kind.

(2) Molybdenite in quartz veins in granite. These may be looked upon as special cases of pegmatite dikes in which feldspar and mica are absent or inconspicuous. The deposits of the Kewagama Lake area, Abitibi district are of this kind.

(3) Molybdenite associated with other metallic sulphides in pegmatite dikes particularly at the contacts with intruded rocks. Examples of this type are found in the deposits of Aldfield, Masham and Egan townships.

(4) Molybdenite in green pyroxene rock at its contact with crystalline limestone or gneiss. The pyroxene may have resulted from the metamorphic action of granite intrusions which also may have brought the molybdenite. Most of the southeastern Pontiac deposits and some of those in the north Gatineau region belong to this type.

The large production of molybdenite already to the credit of Quebec has been from properties in the better known parts of the province. It is obvious that these regions, Hull and Pontiac counties, are still capable of large production of the mineral. The Abitibi district has numerous deposits of the quartz vein type, likely to develop into steady producers and to be capable of deeper mining than is profitable in the

more bunchy, scattered deposits of other kinds. There are many occurrences of molybdenite reported along the north shore of the Gulf of St Lawrence, and some of these are thought to be capable of profitable mining. These discoveries also are in parts of the province that are a good deal travelled. When to the known molybdenite occurrences are added the possibilities in the vast unexplored regions of favorable rocks, it is seen that Quebec may be able in the future to supply a large demand for molybdenite.

The total production of molybdenite in the Province of Quebec in 1926 was 25,168 pounds valued at $10,-472.

ABITIBI DISTRICT

The Abitibi district extends from Lake Abitibi at the Ontario boundary eastward 225 miles, with an average width of about 70 miles. It is crossed diagonally from northwest to southeast by the Canadian National railway. The molybdenite deposits are about 30 miles south of Villemontel and Amos stations on that railway.

LA CORNE TOWNSHIP

Molybdenite Reduction Company. The claims called the **Eureka Mine** are at the junction of La Corne, La Motte, Malartic, and Varsan townships. The mine can be reached by a canoe or motor boat route up the Harricanaw River and Lake La Motte, or, by the new colonization road, a distance of 25 miles. The molybdenite occurs mainly in sericite schist forming zones of mineralization in pegmatitic granite, but is also found in the pegmatite. About 30 of these zones or

veins have been found, making a combined length of about 4000 feet. Similar veins have been found about three quarters of a mile to the southwest in Malartic township. About 150 tons of 3 per cent ore was taken out for experimental purposes and the ore has been proved to be easy to concentrate. The property is owned by the Molybdenite Reduction Company Limited. A mill has been built and concentrates produced from ore said to average two per cent of molybdenite.

PREISSAC TOWNSHIP

Indian Peninsula. The property of the **St. Maurice Mines Co., Ltd.**, is on Indian Peninsula, Kewagama Lake, 20 miles southwest of Amos, on the Canadian National railway. By motor boat up the Harricanaw River with a tramway portage to Kewagama Lake, the distance is 52 miles. By winter road from Villemontel station on the Canadian National railway the distance is 21 miles. Indian Peninsula is a 10-mile spur, chiefly granite, projecting southward into Kewagama Lake. Within the granite are many quartz veins, aplite dikes, and schisted areas rich in quartz. The molybdenite is associatd with quartz and greenish white mica. On the Huestis, Sweezey, and Doucet claims, about 16,000 feet of quartz veins are exposed. One vein is at least 2000 feet long. About 20 veins carrying molybdenite have been located. Those on the Sweezey claim are considered to be the most promising. The unselected ore may average about 1 per cent molybdenite, but it has the advantage of being free from pyrite, and selected milling ore carries as high as 5.1 per cent of molybdenite. Bismuthinite is found in these veins, and may form a valuable by-product.

Nearly every exposure of granite in the vicinity of Kewagama Lake shows quartz veins from a few inches to 15 feet wide, all carrying more or less molybdenite and bismuthinite. One specimen of quartz carried 117 ounces of gold to the ton, a rare specimen.

Peninsular Mining Syndicate. The claims formerly owned by this syndicate, but now lapsed, are in the central part of the Indian Peninsula. There are many quartz veins on the claims and molybdenite can be seen in some of them.

Dion Claim. This adjoins the southeast corner of the Sweezey claim, and covers part of the granite-schist contac.t A little ore has been taken out for test purposes.

Kewagama River. The claims of the **Height of Land Mining Company** are about 2 miles north of Kewagama Lake. A quartz vein 15 feet wide carries large molybdenite crystals in white mica along the contact of the quartz vein and the granite in which it lies. Bismuthinite is scattered through the middle of the vein. About 7 tons of one per cent ore had been taken out in 1925. Some large crystals of beryl have been taken out. Phenacite, a silicate of beryllium, has also been found. A dike of granite shows a mass 30 feet long and nearly a foot wide made up of molybdenite and coarse muscovite.

CHICOUTIMI DISTRICT

METABETCHOUAN TOWNSHIP

Lake St. John. Molybdenite occurs in a railway cut a mile and a half east of Chambord junction, on the

Quebec and Lake St. John railway. The molybdenite is found in a pegmatite dike in gneiss, and the mineralization extends into the gneiss. Assays showed that the molybdenite carries gold.

GULF OF ST. LAWRENCE

About 200 miles east of Quebec city, opposite the island of Anticosti are molybdenite deposits that are repeated for a distance of about 150 miles eastward along the shore of the Gulf of St. Lawrence.

QUETACHU BAY

Molybdenite occurs in a quartz vein. Some of the crystals are 12 inches across and a quarter of an inch thick. Garnets and black mica are mixed with the quartz. The vein has been traced about 150 feet. It is thought that this deposit might yield a considerable quantity of molybdenite. Quetachu Bay is opposite the centre of Anticosti Island.

ROMAINE

Romaine is at the mouth of Olomanoshibo River, about 70 miles east of Quetachu Bay. Molybdenite deposits occur on McKenzie Island and other islands in the vicinity. It is found in quartz-feldspar stringers in gneiss. Considerable work has been done on McKenzie Island and ore taken out for concentration tests.

OTHER DEPOSITS

Molybdenite occurs near the mouth of Little Mecatina River, and near the head of Ha-Ha Bay.

HULL DISTRICT

EARDLEY TOWNSHIP

National Molybdenite Company. The claims of this company are on lot 1, range seven, on top of the Eardley escarpment about 4 miles northeast of Breckenridge station on the Ottawa-Waltham railway. The molybdenite is found in pyroxenite-gneiss that is cut by pegmatite dikes. The gneiss has apparently been formed by the metamorphosis of crystalline limestone. The best ore is associated with the pyroxenite. Bands of pink calcite occur and molybdenite is found in it near the pyroxenite. The property has been developed by a number of test pits.

Wood-Ormond Prospect. This prospect is on lot 6 south half, range eight. Molybdenite is found in bands of green hornblende in red granite. The mineral seems to be confined to the hornblende. The ore is fairly rich, but apparently limited in extent.

Chatelain Prospect. This is on lot 6 south half, range eleven. It is near the south shore of Harrington (Mouseau) Lake. The ore consists of a flat quartz stringer carrying molybdenite, pyrite and pyrrhotite. The flatness of the deposit gives it the appearance of being much larger than it really is.

EGAN TOWNSHIP

McKerracher and Wanless Claims. These are on lots 6 and 7, range three, near the east bank of Desert River, and 4½ miles northwest of Maniwaki, the terminus of the Gatineau railway. Molybdenite is found in mineral zones along the contact between crystal-

line limestone and gneiss. These mineral zones are made up of parallel bands of pegmatite and pyroxenite, with pyrite and pyrrhotite. Three such zones are known. About 30 tons of ore has been shipped from this property.

La Fleur Prospect. This is on lot 69, range four, about 15 miles north of Maniwaki. It was first worked about 30 years ago. The molybdenite occurs in a mineral zone along a contact between crystalline limestone and gneiss. There are parallel stringers of pyrite in pyroxene-feldspar rock.

HULL TOWNSHIP

The **Payne** prospect on lots 27 and 28, range ten, and the **Blackburn** prospect on lot 13 north half, range eleven, have molybdenite deposits in and near pegmatite dikes cutting gneiss.

MASHAM TOWNSHIP

Bain Property. This property is on the north shore of Indian Lake, about 36 miles northwest of Ottawa. The molybdenite is found in mineralized zones at and near the contact of pegmatite dikes with gneiss and crystalline limestone. Green pyroxene, pyrite, and pyrrhotite are abundant. There has been a good deal of development work done, and around the main pit an area of about 3000 square feet shows a promising deposit of ore. This deposit has been traced for more than a quarter of a mile. Representative samples run from 1.97 to 3.66 per cent of molybdenite.

PONTIAC DISTRICT

ALDFIELD TOWNSHIP

Ross Property. This is about 15 miles northwest of Wakefield station on the Gatineau railway. The molybdenite is found in mineral zones in gneiss with irregular masses of pyroxenite. Some very large crystals have been taken out, one said to have been 2½ pounds in weight, but the general run of the ore is not more than 0.5 per cent.

Ranges Four and Five, lots 1, 2, and 3. These deposits are near the boundary between Aldfield and Masham townships. The molybdenite occurs in mineralized zones much as on the Ross property. There is an area of about 12 square miles, radiating from the northwest corner of Masham township, that is well-mineralized and underlain by rocks favorable to the occurrence of molybdenite. This area may repay careful prospecting.

Moodie Prospect. This prospect is on the farm of R. Mattock, near Martin Lake, 18 miles north of Shawville station on the Ottawa-Waltham railway. The molybdenite is in masses of pyroxene in crystalline limestone. Pegmatite dikes cut the limestone not far away.

BRISTOL TOWNSHIP

Dagg Prospect. This is on lot 3, range twelve, one mile south of Philip Lake. The molybdenite is found in a mineral zone at the contact between pegmatite and crystalline limestone. The contact zone consists of pyroxene with stringers of pyrite. The molybdenite occurs with the pyrite, scattered through the pyrox-

ene, and to a smaller extent in the pegmatite. The small amount of ore taken out assays about one per cent of molybdenite. The area in which this prospect lies is favorable for the occurrence of workable deposits of molybdenite. (See Clarendon Township, Tippin and Welsh prospects).

CLAPHAM TOWNSHIP

Farrell Prospect. This prospect is a little east of E. Pelliter's farm, about 20 miles northeast of Shawville on the Ottawa-Waltham railway. The molybdenite is found in bands of pyroxenite that are associated with pegmatite dikes intruding granite and gneiss. The deposit is on a hillside that is composed of mineralized rocks. Further prospecting may bring to light other deposits.

CLARENDON TOWNSHIP

Tippin Prospect. This is on lots 4 and 5 south half, range twelve. The deposit is along the contact zone between crystalline limestone and gneiss where the limestone has been altered to pyroxene, etc., by intrusive pegmatite dikes. The stripping and test pits show a deposit of considerable extent, but the ore that has been taken out is low-grade. This prospect is southwest of the Dagg prospect in Bristol township. These with the Welsh prospect are on a mineralized zone of favorable rocks that may repay more extended prospecting.

Welsh Prospect. This is about a quarter of a mile southwest of Philip Lake, on lot 1, range thirteen It is about 9 miles north of Shawville on the Ottawa-Waltham railway. The deposit seems to be a continu-

ation of that on the Tippin prospect about 2 miles to the southwest. The molybdenite is in pegmatite and green pyroxene. A large tonnage of medium grade ore might be taken out. That on the dump in 1925 was about one per cent ore.

About half a mile south is an unprospected show of molybdenite on the farm of Henderson Harris.

HUDDERSFIELD TOWNSHIP

Chabot Mine. This property is 4 miles south of the Squaw Lake camp. It is on lots 20, 21, and 22, range five. The molybdenite is disseminated through masses of pyroxene in contact with granite. The molybdenite is closely associated with calcite. Selected ore assayed 4.63 per cent of molybdenite. Another lot of 3 tons of hand-picked ore assayed 1.4 per cent.

Squaw Lake Mine. This property is on lots 19 to 26, range eight, at the eastern end of Big Squaw Lake. The molybdenite deposits are at the contacts of numerous pegmatite dikes with crystalline limestone, gneiss, and quartzite. The limestone has in places been altered to pyroxenite, which is generally mineralized. The richest ore is found where the pegmatite dikes cut the pyroxenite. In some places it is scattered through the pegmatite. It is usually accompanied by pyrite and pyrrhotite. There are indications that the deposits are shallow. A considerable quantity of ore has been taken out.

LITCHFIELD TOWNSHIP

Bolan Prospect. This proprety is on lot 26, range nine, about 10 miles north of Campbell's Bay on the

Ottawa-Waltham railway. Molybdenite is found disseminated in bands and patches of pyroxenite. The ore is low-grade, one lot of 15 tons averaging 0.75 per cent.

Crawford Prospect. This is about a mile and a half east of the Bolan prospect Pyroxenite bands showing flakes of molybdenite outcrop in several places between the two prospects. About 15 tons of ore averaged a little over one per cent of molybdenite.

Giroux Prospect. This property is on lot 21 southwest half, range eleven, near the east shore of Bear Lake (Lac L'Ours). The molybdenite occurs in green pyroxene rock which is plentiful over at least 5 or 6 acres. In some places there are intrusive dikes of pegmatite. There has been a good deal of development work, and it should not be difficult to take out high-grade hand-picked ore.

ONSLOW TOWNSHIP

Moss Mine, also called **Quyon Mine.** This property is 3 miles north of Quyon station on the Canadian Pacific railway. The mine has produced over 80 per cent of the Canadian output of molybdenite since 1916. From 1916 to 1919 inclusive, the total output of this mine was 765,091 pounds of molybdenite. The country rock is mostly fine-grained pink granite and syenite cut by many small dikes of pegmatite and aplite. The molybdenite is found in masses of darker rock consisting mainly of granular quartz and feldspar. Pyrite, pyrrhotite, fluorspar, and pyroxene accompany the molybdenite. The molybdenite is mostly disseminated in flakes through the pegmatite and aplite, and

the mining has been carried on so as to give ore of an even grade. Mining has been done both by open pit and by shaft and drifts. The shaft was sunk 200 feet. The amount of waste in the rock mined was small, not much more than 10 per cent. Diamond drilling has shown that the main ore body does not continue unbroken, but at a depth of about 275 feet it breaks up into prongs that gradually taper. It is probable that there is still unmined around the pit in the main ore body as much ore as has been taken out, but the grade may be a little lower. The amount taken out from 1916 to 1919 inclusive was 61,000 tons, of which 58,000 tons was milled. The average recovery was 0.66 per cent of molybdenite, but during 1918 and 1919 it was only 0.5. In the earlier years only the richer, selected ore was milled. A second deposit (No. 2) should yield a considerable tonnage of ore. There are other showings on the property, and room for a good deal of prospecting.

THORNE TOWNSHIP

Riley Prospect. This is on the farm of James Riley of Ladysmith, about 15 miles north of Shawville on the Canadian Pacific railway. Pegmatite dikes and bands of pyroxene in gneiss occupy a wide area. Molybdenite occurs in seams of pyrite and also disseminated through the pyroxene. Hand-picked ore carried 1.03 per cent of molybdenite.

The following tabular statement has been taken, with some modifications, from **Molybdenite**, by V. L. Eardley-Wilmot, Mines Branch, Ottawa, publication No. 592.

Molybdenite Deposits in Quebec

Township	Name and locality	Mode of occurrence	Quantity of ore shipped	Classification	Remarks
		ABITIBI DISTRICT			
Preissac	Indian peninsula, St. Maurice mines	Quartz veins in granite and sericite schist	$1\frac{1}{2}$ ton for testing	B.	Extensive strippings and pits; small Groch concentrator
"	Kewagama river, Height of Land Mining Co.	Pegmatite veins in schists	1,200 pounds pure flake	C.	Open-cuts; 50-foot shaft and tunnel; about 7 tons 1% ore extracted
"	Kewagama river, McLaren	In small quartz veins in granite and biotite schist	Nil.	P.	2 deep trenches ....
"	Kewagama river, Small	In quartz veins in granite and schist	"	P.E.	2 trenches ....
LaCorne	R. I, Lots 1 and 2.... Benjamin	Quartz veins in sericite schist and in pegmatite granite and mica schist	"	A.	1,000 feet trenching; 15 pits; property in four townships: 150 tons 3% ore extracted
		HULL DISTRICT			
Eardley	R. VII, Lot 1, National Molybdenum Company's mine	Fine flakes in Grenville limestone and coarse flakes in pyroxenite	35 tons, 460 lbs. of MoS^2 recovered	B.	Many local occurrences; 40-foot shaft, 6 pits, and stripping
"	R. VIII, lot 6, Wood-Ormond	Associated with dark green pyroxene in red granite	Nil.	D.	Two tons ore extracted. Two open-cuts
"	R. XI, lot 6, Chatelain	In pegmatite quartz in red granite with pyrites and pyrrhotite	"	E.	Stripping in creek bed, about 4 tons 1.5% ore extracted
"	R. III, lots 6-7, McKerracher	Sulphide contact zones between gneiss and limestone	30 tons	C.	Several open-cuts and pits, ore low grade and pockety; machinery and buildings on property

Molybdenite Deposits in Quebec—Continued

Township	Name and locality	Mode of occurrence	Quantity of ore shipped	Classification	Remarks
		HULL DISTRICT—	*Continued*		
Egan	R. III, lots 8-13, Moore	Sulphide contact zones between gneiss and limestone	Nil.	C.	Few small pits. A continuation of McKerracher prospect
"	R. IV, lot 69	Massive flakes; much decomposed iron sulphides in limestone	"	C.	Pit and tunnel ....
Hull	R. X, lots 27 and 28, Payne	Same as National Molybdenum Company	"	C.	One open-cut; $\frac{1}{4}$ tons 0.5% ore extracted
"	R. XI, lot 13, Kirk Ferry	Pegmatite contact with gneiss and limetone	"	M.C.	No development; exposure in railway-cut
Masham	R. X, lots 53-55, Bain	Highly pyritiferous contact pyroxenite zone; pegmatitic granite and gneiss	1 ton	A.	About 25 pits and stripping; several hundred tons of good ore extracted
"	R. X, lots 56-57, Edwards	Pyrites with contact pyroxenite in biotite-gneiss	Nil.	E.	Two small pits, close to Bain deposit
		MEGANTIC DIS	TRICT		
Leeds	R. XV, lot 17, Harvey Hill	Semi-amorphous in copper-bearing slates	Nil.	C.	Extensive development for copper only
		PONTIAC DISTRICT	(*Southeast*)		
Aldfield	R. III, lots 1 and 2, Ross	With other sulphides in contact pyroxenite in biotite gneiss and green pyroxene	About 30 tons	C.	Four or five pits and open-cuts; shipments very low grade but better ore on property
"	R. IV and V, lots 1 to 3, Kirkham	In flat pyritic seams in gneiss and pyroxenite	Several tons	C.	Several open-cuts ....
"	R. VI, lot 53, Moodie	Clean flakes in massive pyroxene in white limestone and pegmatite	Nil.	D.	One trench: 3 tons 0.75% ore extracted. Iron pyrites absent

Molybdenite Deposits in Quebec—Continued

Township	Name and locality	Mode of occurrence	Quantity of ore shipped	Classification	Remarks
		FONTIAC DISTRICT (*Southeast*) — *Continued*			
Alleyn	R. II, lot 1, Heeney .	In pegmatite dike in hornblende gneiss	80 pounds flake	E.	One small pit ....
Bristol	R. XII, lot 3, Dagg..	In pyritic stringers with pyroxenite in limestone and pegmatite	Nil.	D.	3 pits; 1 ton 1% ore on dump
Clapham	R. II, lot 6 and 7, Farrell	In pyritic and pyroxene stringers in pegmatite and granite	1 ton cobbed ..	C.D.	Little quarrying and stripping
"	R. XII, lots 4 and 5, F. Tippin	Pegmatite and pyroxenite zone; little pyrites; in altered limestone and gneiss below red granite	10 tons	E.D.	Deep open-cut, pits and stripping
"	R. XIII, lot 1, Welsh	Disseminated through pegmatite gneiss; pyrites almost absent	Nil.	B.	Tunnel, pits and shafts; a few tons extracted
"	R. XIII, lots 26-27, Richardson	....	"	P.	Little prospecting; some ore extracted
Huddersfield	R. V, lots 20-22, Chabot	Disseminated through massive pyroxene in altered limestone	5 tons cobbed..	D.	Fairly extensive trenching and pits
"	R. VIII, lots 19-26, Squaw lake	In lenses of pyroxenite with pyrites in altered limestone and gneiss	700 pounds concs.	C.	5 open-cuts and trenches; 3 D.D. holes; deposits shallow, all ore extracted; 25-ton concentrator
"	R. VIII, lot 27 Moyle	" " "	Nil.	E.	900 feet of trenches and pits

Molybdenite Deposits in Quebec—Continued

Township	Name and locality	Mode of occurrence	Quantity of ore shipped	Classification	Remarks
PONTIAC DISTRICT (Southeast)—*Continued*					
Litchfield	R. VIII, lots 14 and 15, Ranger	In pyroxenite in limestone	Nil.	E.	Very little prospecting; small quantity extracted
"	R. IX, lot 26, Bolan..	Large flakes in pyroxene bands in granite-gneiss	1 ton	D.	1 cut and 3 test pits; 15 tons of 0.75% clean ore extracted
"	R. IX, lot 28, Crawford	Highly altered sulphide zone in red granite and gneiss	Nil.	D.	Stripping and 3 small shafts 15 tons of 1.0% ore extracted
"	R. X, lot 3, Davis....	Contact pyroxene and pegmatite in gneiss and altered limestone	"	E.	Stripping and a few pits...
"	R. XI, lot 21, Giroux	Large lumps in massive green pyroxene in greenish schistose rock; also pegmatite and granite	"	D.B.	Quarrying and many test pits; about 60 tons of ore extracted
Onslow	R. VII, lots 9 and 10 Moss mine	Small flakes disseminated through highly altered limestone and massive pink syenite	58,000 tons milled	A.	Very extensive pits and shafts; tunnels; 12,000 feet D.D. holes; 80% of Canadian output; considerable ore in sight; 150-ton Callow concentrator; 388 tons MoS_2 produced
Thorne	R. I, lot 3 Welsh, No. 2	Decomposed pyrite stringers in syenite gneiss and pegmatite	"	E.	5 small pits ....
"	R. IV, lot 2, Riley...	Pyrite seams in pyroxenite and pegmatite	750 pounds cobbed	C.	Strippings and pits ....

Molybdenite Deposits in Quebec—Concluded

Township	Name and locality	Mode of occurrence	Quantity of ore shipped	Classification	Remarks
		SAGUENAY DISTRICT			
	North shore, gulf of St. Lawrence near Quetachu bay	In quartz and pegmatite dikes in granite and mica schists	2 tons	C.	Very little prospecting but known 60 years ago
		TERRITORIES			
Abitibi	Plamondon hill, Turgeon basin	In pegmatite dikes in granite and hornblende schist	Nil.	M.	No development ....
Mistassini ...	East coast of James bay. Paint Hills islands	Associated with feldspar dikes in quartz and red feldspar	"	M.	" ....
New Quebec	East coast of Hudson bay; north of Great Whale river	....	....	....	Reported occurrence .....

In addition to the above, some half dozen other occurrences have been noted, about which no information is available. In the above tabulation the following *tentative* classification has been adopted for grading purposes.

A. Economic conditions favourable, and probably a considerable producer.
B. Probable producer.
C. Has possibilities and worthy of further investigation.
D. Has possibilities on a small scale, suitable for economic hand-cobbing.
E. Prospect not very encouraging.
P. Prospect—no definite information.
M. Mineral occurrence only.

TITANIUM

INTRODUCTION

Titanium is widespread in the earth's crust, forming about 0.44% of the total as far as known. The chief minerals occurring in commercial quantities available for the manufacture of titanium products are the oxide of titanium, **rutile,** containing 59% of titanium, and **ilmenite,** an oxide of titanium and iron, of variable composition, but containing theoretically about 31.5% of titanium. Deposits of rutile of commercial importance are very rare, there being only four deposits at present known, at Kragero in Norway, in Nelson County, Virginia, at St. Urbain, Quebec, and at Mount Crawford, South Australia. In addition to these sources, a little rutile is produced by the washing of sands, for example, along with monazite, zircon, etc., at Pablo Beach, Florida. Deposits of ilmenite are much more numerous and widespread. A great many deposits of iron ore contain titanium, and when the amount of this element is above 2 or 3%, the iron ore is not acceptable at the blast furnace. On the other hand, ore containing less than 15 to 18% of titanium is not at present acceptable for the manufacture of titanium products. As there are many bodies of magnetite mixed with ilmenite in various proportions, there is a wide range of **titaniferous magnetites** for which there is at present no demand, namely those containing from 3% to 15% of titanium. (The percentage of titanium is often stated as **titanic acid** or **titanium dioxide** or TiO_2. To convert this into the percentage of titanium, it is only necessary to multiply by 6 and

divide by 10. To convert percentage of **titanium** to percentage of **titanic acid,** multiply by 10 and divide by 6.) The Norwegian ore of titanium carries from 25 to 45% of titanium dioxide equal to 15 to 27% of titanium.

The market price for rutile is 10 cents a pound for rutile carrying 94% of titanium dioxide, and for ilmenite $9.50 to $11 a ton for ilmenite carrying 52% of titanium dioxide, nearly pure mineral. For 32 to 35%, $7 to $8 a ton.

The uses of titanium products are numerous and growing in importance, but the amount of ore required to meet the present demand is small, probably not more than 15,000 to 20.000 tons a year of rutile and ilmenite combined. The principal products, requiring by far the greater part of the ore produced, are **ferrotitanium** and **ferrocarbontitanium** used in the purification of steel, and, of late years, **titanium white,** a substitute for white lead in the manufacture of white paint. **Ferrotitanium** is made from ilmenite by the thermit process, that is, by reducing with aluminum at the high temperature caused by touching off a mixture of the ground ore with powdered aluminum. The aluminum is oxidised at the expense of the ore in which both iron and titanium are deprived of their oxygen. The product contains about 25% of titanium. **Ferrocarbontitanium** is made by reducing ilmenite with coke in an electric furnace. The product contains 15 to 18% of titanium and 5 to 9% of carbon. It sells for $160 a ton.

The addition of a small percentage of titanium to manganese steel and nickel steel is said to improve their forging qualities.

Cuprotitanium is made by reducing rutile in an electric furnace in a bath of aluminum to which copper has been added. The aluminum removes the oxygen from the rutile and the titanium alloys with the copper. The product is used to improve the quality of copper for making copper castings.

Manganotitanium, made by the thermit process, has been proposed as a deoxidiser of bronze in castings.

Titanium carbide, made by reducing titanium dioxide with coke in an electrical furnace, is an extremely hard material used in the the manufacture of **arc light electrodes**. Ilmenite and rutile are used for the same purpose. In the **magnetite lamp**, the cathode is made of magnetite with 15 to 20% of rutile and a certain amount of chromite. The magnetite is used because of its conductivity for electricity. Rutile and other titanium compounds are found to be superior to all other materials in giving efficiency to the light.

Metallic titanium is difficult to manufacture pure. Hunter's method of reducing titanium tetrachloride with metallic sodium gives the pure metal, but is too costly for commercial purposes. Electric lamp filaments made of titanium give a white light of great efficiency and will probably come into use as soon as a suitable method of manufacture is found. The impure metal, 80 to 90%, sells for $5 a pound.

Titanium white or **titanox** is pure titanium dioxide made from ilmenite by a process that makes the prod-

uct rather high-priced. In spite of this, its great superiority in covering power and durability gives it such an advantage over the older white paint materials that it is likely to come into general use. The absence of any poisonous quality gives it an additional advantage over white lead. Titanox is manufactured by The Titanium Pigment Company, Inc. at Niagara Falls, N.Y. It has been announced that a factory is to be built in Vermont to make titanium white from Quebec ilmenite. The Titan Company, of Norway, uses ilmenite containing 25 to 45% of titanium dioxide, equal to 15 to 27% of titanium. As the poisonous character of white lead is causing more and more uneasiness regarding its use as a paint, it is likely to be displaced by titanium white, which will then become the chief titanium product manufactured.

A number of titanium compounds are used as colors and mordants in the dyeing industry. Several pigments with a titanium base are used as colors for porcelain, including **titan yellow** made from rutile. Rutile is used to give the very pale yellow color to artificial teeth.

There is a wide range of titanium compounds, and as these are studied many of them will be found useful.

Titanium Ores in Quebec

Rutile. This is natural titanium dioxide. It is a hard mineral usually red or reddish brown in color, but sometimes yellowish, bluish, violet, black or green. The crystals are four-sided prisms. It is found as a constituent of a great variety of rocks, igneous, sedi-

mentary and metamorphic, and also sometimes in veins. Though so common in rocks and veins, rutile rarely occurs in sufficient concentration for commercial purposes. Most of the known workable deposits are associated with gabbro or anorthosite. Some deposits in pegmatite dikes may be workable.

CHARLEVOIX COUNTY

St. Urbain

Rutile occurs in considerable quantity in the General Electric Company's ilmenite deposit about two miles west of the village of St. Urbain. The rutile-bearing ilmenite is in bands and patches distinguished from the rest by the brown tint due to the rutile. These bands and patches average about 6% of rutile, but the proportion varies a good deal. The titanium in the ore varies from 25 to 32%. At intervals from 1910, ore has been shipped to Schenectady, N.Y.

HULL COUNTY

Rutile has been found in small quantities at several places in Templeton township. Its occurrence in an apatite deposit on lot 10, range ten, has been reported. Large crystals occur in a barite vein and in the calcite bordering it, on lot 13 of range thirteen, and on lot 12 of range eleven.

BEAUCE COUNTY

In washing for gold, rutile has been noticed in the concentrates.

BROME COUNTY

Rutile (or perhaps brookite of the same composition) was found with chlorite, specular hematite, and feldspar in Sutton township.

Ilmenite. Ilmenite is an oxide of iron and titanium of somewhat variable composition, but theoretically containing 52.7% of titanium dioxide, equal to 31.62% of titanium. It is a hard, black, heavy mineral. It looks much like magnetite, but is duller in lustre and only slightly if at all magnetic. It however often occurs intimately mixed with magnetite and a small proportion of the latter makes the whole mass distinctly magnetic. These mixtures of ilmenite and magnetite are rather common in Quebec. As titanium ore they are not to be considered unless they contain at least 15% of titanium.

CHARLEVOIX COUNTY

St. Urbain

St. Urbain is about 9 miles north of Baie St. Paul on the north shore of the St. Lawrence River below Quebec city. The St. Urbain deposits of ilmenite have been known for a long time, and were first worked in 1872 as iron ore which was smelted in a blast furnace at St. Urbain between 1872 and 1874. They occur in anorthosite in large masses, elongated in the direction of a somewhat gneissic structure shown by the anorthosite in their neighborhood.

Coulomb's Mine is on lot 319. The workings show large masses of solid ilmenite. It carries from 21.30 to 24.62% of titanium, and from 40.09 to 42.89% of iron. It is low in sulphur and phosphorus. Ore has been hauled to Baie St. Paul and shipped to the Titanium Alloy Company of Niagara Falls, N.Y.

The **General Electric Mine** shows two bodies of ilmenite, one 80 feet and another 50 feet wide. Diamond

drilling shows a depth of 100 feet. This ore carries 24.98% of titanium and 44.52% of iron. It is low in silica (1.10%) and shows only traces of sulphur and phosphorus.

The **Glen Prospect** is on lot 31 of the St. Urbain range. The ore on this property carries 23% of titanium and 43.06% of iron. It is low in silica, sulphur, and phosphorus.

Shipments have been made from other deposits in the vicinity owned by the Baie St. Paul Titanic Iron Ore Mining and Exporting Company.

Some of the St. Urbain ilmenite deposits have bands of ore in which the titanium content is increased by the presence of rutile.

Bouchard's Mine is on lot 622 of the St. Jérôme range, about half a mile from the Glen prospect. The ore contains 22% of titanium and 33% of iron. It is high in sulphur and phosphorus. The deposit is narrow and irregular. Shipments have been made to Niagara Falls, N.Y.

Furnace Mine. This gets its name from the charcoal blast furnace built in 1871 to make pig iron from the ore. It is northeast of the General Electric Company's mine. The ore deposit is of considerable size. The ore carries from 23 to 24% of titanium, about 45% of iron, and a little vanadium and chromium.

Bignell Prospect. Test pits on lot 608 of the St. Jérôme range showed a deposit of ilmenite, but the extent of the deposit is not known. This deposit is about half a mile west of a line drawn through the productive deposits already mentioned.

Lot 641, St. Thomas Range. About $2\frac{1}{4}$ miles west of the Bignell prospect, ilmenite occurs mixed with feldspar.

Décharge Range. A band of ilmenite mixed with feldspar, etc., occurs on the east bank of the Gouffre River about 3 miles above the village of St. Urbain.

Quebec Seminary Lands. Ilmenite occurs in the seigniory of Beaupré about 18 or 19 miles north of St. Urbain. The extent of the deposit is not known. The ilmenite carries about 19% of titanium and 50% of iron. It is low in sulphur and phosphorus.

TERREBONNE COUNTY

Ivry Deposits

The Ivry ilmenite deposits are on lots 37 and 38 of the fifth range, Beresford township, Terrebonne county. The workings are about 3 miles from Ivry station on the St. Jerome branch of the Canadian Pacific railway. The deposits are extensive, having been traced for a length of over 700 feet and a width of 120 feet. The country rock is dark purple anorthosite. The ore carries 18 to 22% of titanium and 47 to 48% of iron. It also contains a little vanadium and chromium. These deposits are favorably located near the railway, and their large size and situation in a hillside makes them easily mined and shipped Since 1912, 16,000 tons or more has been shipped to the Titanium Alloy Company, Niagara Falls, N.Y.

WOLFE COUNTY

Lake Nicolet

Ilmenite occurs on lot 20 of the eleventh concession, Ham township, near the northwest shore of Lake Ni-

colet. This deposit, in the Eastern Townships, differs from those on the north side of the St. Lawrence River all of which are found in anorthosite. The Lake Nicolet deposit is in serpentine. The ore carries 15.9% of titanium and 46.5% of iron. It also carries chromium 1.16%. The extent of the deposit is not known.

OTHER OCCURRENCES OF ILMENITE

Ilmenite has been observed at a number of other places around the anorthosite mass north of Montreal, and also in the great masses of anorthosite along the north shore of the river and gulf of St. Lawrence. About a mile and a half north of the mouth of Thunder River (Rivière au Tonnerre) is a body of ilmenite 50 feet long and up to 35 feet wide. It carries 49.75% of iron and 21·2% of titanium.

Reference: Titanium by A. H. A. Robinson, publication No. 579, Mines Branch, Ottawa.

TUNGSTEN

The metal tungsten, once only a curiosity, has become of late years a valuable material for tungsten steel, also called wolfram steel, and as a constituent of other alloys. Tungsten steel is harder and tougher than ordinary steel. It is also self-hardening, so that tools made of it do not require tempering. On account of its high fusion temperature (5576° Fahrenheit) and its power of radiating white light, tungsten is extensively used in making the filaments of electric light-bulbs. Compounds of tungsten are used as mordants in dyeing and for weighting silk. They are also used in making cotton fabrics fireproof.

The principal tungsten minerals are as follows:

Wolframite, a tungstate of iron and manganese, is a very heavy black or brown-black mineral. It turns reddish brown when rubbed to a fine powder.

Huebnerite, a tungstate of manganese, is much like wolframite, is reddish brown in color, and is yellowish brown when finely powdered.

Ferberite is tungstate of iron. It is a heavy black mineral, rather soft, and powdering brownish.

Scheelite, tungstate of lime, is a heavy mineral of a creamy white, yellowish or light brown color. It looks somewhat like calcite or orthoclase, but is much heavier.

Tungstite is a decomposition product of the other tungsten minerals and occurs as stains or crusts of a golden yellow color. It is seldom found in quantities of economic importance.

Tungsten minerals are found in the rocks with which tinstone deposits are associated, and also in quartz veins in gold regions. The tungsten minerals are sometimes found in quartz veins barren of gold, and sometimes in auriferous veins. As a rule, however veins rich in gold are poor in tungsten minerals, anc those rich in tungsten minerals are poor in gold. Wolframite and huebnerite are easily distinguished in the quartz by their brown color, good cleavage, weight, and comparative softness. They are easily scratched with a knife, whereas quartz is harder than steel. Quartz veins carrying these minerals are apt to have the walls of cracks covered with a black coating, probably oxides of manganese, or possibly ferberite.

The tungsten minerals should therefore be sought in the gold fields of Canada, and also in those regions where granite intrusions have given rise to pegmatite dikes and irregular quartz veins that are looked upon as similar in origin to the dikes, as it were, dikes that happen to be composed altogether of quartz. These veins may be found at the edge of the granite or in the rocks intruded by the granite, such as gneiss, schists, and slate. The veins may occur in these rocks at considerable distances from the outcrops of granite. In south Dakota wolframite has been found associated with siliceous gold deposits in dolomite.

Scheelite occurs in quartz veins cutting slate in Marlow township, Beauce county, lot 1, range VII.

No important deposits of tungsten minerals have been found in the province of Quebec.

VANADIUM

Vanadium is a rare metal found as a constituent of certain minerals but never native. It is not used as a separate metal, but mostly as a constituent of alloy steels. Large quantities of vanadium steel are used in the manufacture of automobiles and other structures in which a combination of strength with a small weight of steel is desirable. The use of vanadium steel would doubtless be much extended, if the supply were increased, but the vanadium minerals so far drawn upon are scarce, and it is said that the visible supply is nearing exhaustion.

Vanadium Minerals

Patronite is a sulphide of vanadium found in Peru mixed with a coaly substance. This has been the chief source of vanadium for a number of years.

Carnotite contains uranium and vanadium oxides (See **Radioactive Minerals,** p.159). It has been used as a source of radium rather than of vanadium, the latter being only partly recovered. In Colorado and Utah it is found in sandstone. Its occurrence as a yellow incrustation on ilmenite and titaniferous magnetite is significant in view of the fact that these minerals carry a small proportion of vanadium.

Vanadium in Titaniferous Magnetite. Titaniferous magnetite is a mixture of magnetite with ilmenite (See **Iron** p. 88 and **Titanium** p. 141). So far as analysed for vanadium, the presence of that element seems to be pretty general in titaniferous magnetites. Vanadium was discovered in an analysis of the slag from iron furnaces working on the minette ores of the Alsace-Lorraine region. The proportion of vanadium in the titaniferous magnetites that have been examined for it is from about 0.1% to 0.45%. In ores high in titanium the analysis for vanadium is difficult, and its presence in the ore may be overlooked.

Vanadinite contains vanadium, lead, chlorine and oxygen. It is of a deep, ruby red color, sometimes reddish brown or yellow. It is soft and heavy.

Roscoelite is a variety of mica containing vanadium. Its color is brown or greenish brown.

Vanadium minerals have not been found in the province of Quebec, but it is known that some of the titaniferous magnetite deposits contain a small proportion of vanadium. Deposits of this kind may be found sufficiently high in this valuable metal tc make them commercially important as sources of vanadium.

CHAPTER VIII

METALLIC MINERALS (Cont'd)

ANTIMONY, ARSENIC, BISMUTH, MERCURY, TIN

ANTIMONY

The principal ore of antimony is the sulphide, **stibnite**, but native antimony and other antimony minerals are often found mixed with the stibnite.

Antimony is used as part of the alloys Babbit metal and type metal. A little is sometimes used to harden lead to make shot and bullets. Tartar emetic and a few other medicines are compounds of antimony.

Native antimony and stibnite with a little kermesite and valentinite occur with pyrite and copper pyrites in a schistose, slaty rock on lot 28 (new number 56), range one, South Ham township, near the Quebec Central railway, Southeastern Quebec. The deposit is at a contact of the schist with serpentine and diabase, and is mostly in the form of fillings in the joints and other small openings in the rock. No distinct vein is visible. There are two intrusions of serpentine with slate between them. The serpentine may be continuous under the slate, in which case antimony ore may be found in the space between, but it would not likely continue down to any considerable depth. The proportion of ore increases as the contact is approached.

Some mining was done a good many years ago. The ore contains no gold.

ARSENIC

The principal ore of arsenic is mispickel composed of iron, sulphur, and arsenic. The substance usually called arsenic is a white powder, an oxide of arsenic. Arsenic itself is a tin-white material of metallic appearance, but too brittle to be considered a true metal. It is sometimes found in small quantities (native arsenic) with stibnite, in silver ores, and with other metallic minerals.

Deposits of mispickel are apt to be found in association with the less basic rocks such as diorite, or with acid rocks, like granite. It is most commonly found in quartz veins, which may carry gold in payable quantity. A good deal of the arsenic of commerce is recovered as a by-product in the treatment of ores of gold, silver, lead, and copper.

The percentage of arsenic required to constitute a payable arsenic ore independent of other valuable contents depends on the selling price of white arsenic, which varies through a wide range. Since 1921 the limits have been 5½ cents to 16 cents a pound. For direct treatment arsenic ore must contain not less than 15 per cent of arsenic, and in the absence of other valuable constituents ore that requires concentration previous to treatment probably could not be made to pay with a content of arsenic less than 5 per cent.

So far as the production of arsenic goes as the chief product, the majority of occurrences of arsenic min-

erals are of no importance. The arsenic minerals are found at many localities in the province, and mispickel in particular is a common mineral. While its discovery in small amounts is unimportant, it should always be remembered that the exceptional concentration of the mineral in a large body may be found in the same neighborhood.

Mispickel usually weathers to a whitish or pale yellow crust, sometimes a little rusty. If it contains cobalt, the weathered material may be pink, **cobalt bloom.** Arsenides of nickel weather to a green nickel coating. Some of the arsenic minerals containing both nickel and cobalt weather nearly white, the green of the nickel bloom killing the pink of the cobalt bloom.

Uses of Arsenic

The tin-white metallic-looking element, properly called arsenic is used in the manufacture of metal alloys. It has a hardening effect on soft metals like lead, tin, copper, and zinc, and therefore is used to give this property to lead shot, various bronzes, copper, bearings alloys, muntz metal, and the speculum metal (alloy of copper and tin) for the mirrors of reflecting telescopes. Indian fire is a signal light made by burning arsenic with some material giving a supply of oxygen. When arsenic is exposed to the air for a long time, it oxidises to a grey powder, sometimes used as a fly poison.

By far the most important arsenic product is the oxide, white arsenic, produced by roasting the ores containing arsenic minerals and condensing the arsenical fumes in a "bag house" where the flue gases are fil-

tered through a special kind of cloth. The purified product is used largely in the manufacture of insecticides, that is, preparations for killing insects that destroy agricultural crops. The chief of these are Paris green, calcium arsenate, and lead arsenate. Their use is extending fast and so increasing the demand for white arsenic that the price rises to a high point when the supply fails to keep up with the growing demand. Other arsenic preparations are used for sheep dips, and white arsenic itself is used to poison baits for grasshoppers and cutworms. There are a number of dyes and colors made with arsenic compounds.

Arsenic minerals have been noted in a number of places in the province, but so far not in sufficient quantity to be of importance for arsenic alone. Mispickel occurs frequently in the gold veins of the Temiscamingue district, and it may be plentiful enough in some of these to warrant concentration as a by-product. In Cadillac township at the south end of Kewagama Lake, there is a large body of pyrite and mispickel on the claims of M. J. O'Brien, Limited. On claims owned by the same company in the northwest part of the township, there is a shear zone with lenses of quartz carrying gold, pyrite, and mispickel.

There is a considerable proportion of mispickel in the quartz veins of the Bathurst gold claims south of Pelletier Lake in Rouyn township.

Small veins of smaltite occur in Fabre township. They are of the same age as the important deposits in the Cobalt district, Ontario.

Other occurrences of arsenic minerals in Quebec are mentioned in **Arsenic-bearing Deposits in Canada,** by

M. E. Hurst, Geological Survey, Ottawa, publication No. 2131.

BISMUTH

Bismuth is a rather rare metal, sometimes found native, but more commonly as the sulphide, bismuthinite. Both usually occur in complex ores of other metals such as gold, silver, and copper, and the bismuth is sometimes recovered from these ores as a by-product. Tetradymite is composed of bismuth and tellurium. Native bismuth is found in some gold and silver ores.

Uses. Bismuth is used in making easily fusible alloys (safety plugs, etc.) and a number of medicinal substances.

Chicoutimi County

Jonquiere. Bismuthinite occurs in foliated masses in a pegmatite dike on lot 21 of the north range of the road to Kaskouia. Other minerals in the dike are perthite, black tourmaline, and garnet.

Témiskamingue County

Preissac Township. Native bismuth and bismuthinite occur with molybdenite in pegmatite dikes and quartz veins in the Kewagama Lake area. Bismuthinite is found in considerable quantities on Indian Peninsula, Kewagama Lake, and on the property of the Height of Land Mining Company, Kewagama River. It also occurs on the St. Maurice Mining Syndicate claims. Native bismuth is also found in the last two localities. If these properties are operated

for molybdenite, it is possible that the bismuth minerals may be separated as a by-product. (See **Molybdenum**, p. 121).

MERCURY or QUICKSILVER

The principal ore of mercury is the sulphide, cinnabar, which is usually red or brownish red, somewhat like red hematite, with which it has sometimes been found. The mineral is occasionally gray. It is found in veins in shale and slate, rarely in granite and porphyry. The copper ore, tetrahedrite, occasionally carries mercury in economic quantities. Native mercury is occasionally found in very small drops, usually with cinnabar. The price of mercury tends upwards, as old mines are becoming exhausted.

Mercury ore has not so far been found in the province of Quebec.

TIN

The chief ore of tin is **cassiterite** or **tinstone**, an oxide of the metal. It is a hard, very heavy mineral, and these properties enable it to survive the wear when the rocks in which it is deposited break down. The tinstone is then concentrated, as gold is, in the sand and gravel. Placer tin deposits thus formed are the chief source of the tin ore of commerce.

Tinstone is found in granite country, particularly where the granite is in the form of coarse-grained dikes, pegmatite granite. In the vicinity of tin ore the granite is apt to be a white or gray variety called

greisen, made up of quartz and white mica with little or no feldspar. The tinstone is sometimes in this rock, and sometimes in quartz veins, in pegmatite, porphyry, or in slate and other sedimentary rocks in contact with these igneous intrusives.

Cassiterite is rather hard to identify in the field. It is usually black or dark brown, but sometimes light brown or gray. Its great weight, specific gravity about 7, attracts attention if there is enough of it to make its weight felt. If a piece of tinstone is put in dilute hydrochloric acid with a little zinc, it becomes plated with tin.

The sulphide of tin, **stannite,** is sometimes found in important quantities, usually with cassiterite. It is steel-gray to iron-black, sometimes a little yellowish. It is not so heavy or so hard as cassiterite.

Ore containing from 1½ to 3% of tin can be profitably worked. Tin ore may be found in the same deposits with such radium minerals as uraninite.

Tin is in constant and increasing demand, and, as failing commercial deposits are not replaced fast enough by new sources of supply, the tendency of the price is upwards. The present price (1929) of the metal is about 60 cents a pound.

Cassiterite has been observed in small quantities associated with some of the graphite deposits of Buckingham township.

Considering the widespread occurrence of pegmatite granite and other favorable formations in Quebec, the chances would seem to be good for the discovery of a commercial deposit of tinstone.

CHAPTER IX

METALLIC MINERALS (Cont'd)

RADIOACTIVE AND RARE EARTH MINERALS

RADIUM

The metal **radium** is found in a number of rare minerals, all of which contain also the rare metal **uranium**. The constant association of radium and uranium is explained by an unusual relation between these elements. Uranium is slowly decomposing with the formation of other elements, among which is radium. This takes place so slowly that in 5,000,000,000 years only one half the uranium has changed to radium. Half of the remainder changes in another period of the same length, and so on. Radium itself is an unstable element, and it is this property that gives it its usefulness in treatment of cancer and other diseases, and also its power of permanent luminosity. As it slowly disintegrates, radium gives off radiations that may be compared with light and heat rays. They differ from these, however, in their power of penetrating most substances. Metals, especially lead, are more or less "opaque" to radium rays. Radium bromide or

chloride is kept in lead tubes, not because the lead checks the decomposition of the radium,—no device of man has succeeded in checking, hastening, or retarding that process,—but to prevent the radiations from injuring anyone exposed to them. The radiations have the power of exciting chemical changes, and these changes may be made curative by the destruction of germs and diseased tissues; but they may also destroy healthy tissue. In the early days of experiment with radium, exposure to the radiations, for example by carrying a glass tube of radium bromide in a pocket, caused serious and even fatal ulcers. This power of radium to excite chemical change is sometimes shown by a peculiar discoloration of feldspar and other minerals near a mass of pitchblende or other radium-bearing mineral.

In addition to these rays of great penetrating power radium is constantly shooting off particles of the gas helium (See **Hel'um** p. 313) that have not the same power of penetrating solid substances, but are stopped by a sheet of paper. One of the products of the disintegration of radium is a very heavy gas called **radium emanation.** This gas is collected, compressed into needles or tubes and used in the treatment of cancer instead of the radium bromide or chloride. The gas loses its power in a few days. Radium emanation deposits a kind of lead, differing from common lead in having a somewhat lower atomic weight. This accounts for the presence of a little lead in all uranium minerals.

As the rate of disintegration of uranium is not influenced by circumstances, and since the rate has been

measured, it is possible to calculate the age of a uranium mineral, and hence of the rock in which it is found, by finding the ratio between the uranium and the lead in the mineral. Such calculations show that the pegmatite dikes in which radium-bearing minerals have been found in Canada are about 1000 to 1200 million years old.

The ratio of radium to uranium in uranium minerals is mostly constant. It is as 3.4 to 10,000,000. This works out to about 1 milligram (about 1/70 of a grain) of radium in 8 pounds of uranium oxide (U_3O_8). Thus when uranium minerals are discovered and the percentage of uranium oxide is found by analysis, the amount of radium can at once be calculated.

Radioactive minerals can be tested by their power of affecting a photographic plate or film even when the mineral is separated from the film by cardboard or paper. Since iron is not so easily penetrated by the rays, a key can be photographed by laying it on a sheet of paper placed over the plate and covering the whole with a thin sheet of cardboard on which the mineral is laid. Of course the whole operation must be carried out in such a way that the plate or film is protected from light. There is an instrument called **electroscope** that is commonly used for testing radioactive minerals. The radiations discharge the electric charge that keeps two thin leaves of gold or aluminum apart, and this causes the leaves to approach one another. Another handy instrument, the **spinthariscope**, takes advantage of the fact that when the radiations strike a surface covered with zinc sulphide they cause a spark

of light. These little instruments are handy, require no particular expertness, and are not expensive.

The proportion of radium in the minerals is so minute, and the expense of extracting it is so great, that the price of radium in the form of radium bromide or radium chloride is about a million dollars an ounce. It has been as high as three million dollars an ounce. Very small quantities, measured in milligrams, are powerful in the treatment of cancer and other diseases. The world's total production up to January, 1921, was estimated as about five ounces.

In addition to its use in the treatment of cancer and other malignant growths, radium is used in making luminous paint the luminosity of which continues indefinitely. It is also used to change the color of precious stones. Experiments show that radium increases the rate of growth of plants, and extremely minute amounts such as may be present in tailings from the concentration of radium ores may be useful as agricultural fertilizers.

The principal radium minerals are as follows:

Pitchblende or **Uraninite,** pitch-black, grayish, greenish, or brownish in color, very heavy and fairly hard; the fine powder is brownish black, olive-green or grayish; breaks with a round or somewhat uneven fracture; it contains uranium, lead, radium, and usually a number of other rare metals, also the rare gases helium and argon. There are many varieties of this mineral such as **cleveite, broeggerite, nivenite, etc. Pitchblende** is properly the pitchy mineral with no distinct crystallization and containing little or no thorium, cerium, etc. Uraninite is distinctly crystallized and carries considerable proportions of thorium etc. It is found in pegmatite dikes, while pitchblende goes with silver-arsenic-cobalt ores.

Gummite is an alteration product of uraninite. It occurs in rounded or flat pieces looking much like gum. Its color is reddish yellow, orange yellow, or reddish brown.

Torbernite is a green mineral, often in thin transparent or translucent crystals, sometimes micaceous. It is a hydrated phosphate of uranium and copper.

Autunite is yellow, otherwise much like torbernite in appearance. It is a hydrated phosphate of uranium and calcium.

Euxenite and **Samarskite** are uranium-radium minerals somewhat like pitchblende in appearance but not so heavy.

Uran-ochre is a yellow incrustation formed by the weathering of uranium minerals.

Carnotite is a canary-yellow mineral, hitherto one of the chief sources of radium. In addition to uranium and radium, it contains the valuable metal vanadium. It occurs in large quantities in sandstone in the states of Colorado and Utah U.S.A. It has also been found as an incrustation on ilmenite.

Coracite has been described as a distinct mineral, but it is probably pitchblende that has been partly altered to gummite.

Ellsworthite occurs in roundish masses of a yellow or brown color. It contains about 15% of uranium, and in addition the rare elements niobium, tantalum, etc.

Hatchettolite is a mineral somewhat similar to ellsworthite, but lower in uranium.

Columbite and **cyrtolite** are rare minerals of this same family, usually carrying small proportions of uranium, but valuable for their tantalum, zirconium, and thorium content.

Allanite is a black or brown silicate of calcium, iron, aluminum, cerium, etc. It is sometimes radioactive, mostly on account of its thorium content.

THORIUM

The metal **thorium** is also radioactive, and minerals containing this metal show radio activity. Thorium resembles radium in slowly changing into helium and

lead, but at a much slower rate. An intermediate product is **mesothorium** valuable for the very penetrating radiations it gives off. It is used in making luminous paint, but the luminosity lasts only five or six years. All thorium minerals contain some uranium, and uranium minerals commonly carry some thorium. Since radium and mesothorium cannot be separated by chemical operations, it follows that radium products may contain more or less thorium, and mesothorium products contain more or less radium.

Since the thorium minerals are of more importance as the source of products other than mesothorium they are described under another heading (See **Thorium** p. 168).

Uraninite and similar radium-bearing minerals are found in pegmatite dikes, particularly in those containing plenty of quartz and having the quartz and feldspar in separate large masses rather than in the well-mixed condition. But euxenite, samarskite, and the tantalum-niobium-thorium minerals are more likely to occur in graphic granite and other dikes in which the feldspar and quartz are mixed rather than in separate large masses.

The radioactive minerals are not likely to be noticed on the surface, but yellow or orange stains may call attention to their presence. Another indication is the peculiar reddish color of the feldspar in the neighborhood of the radioactive minerals. The feldspar, quartz, or mica in which a mass of radioactive mineral is embedded shows cracks radiating from the mass. As magnetite and ilmenite are sometimes found in pegmatite dikes, they might be mistaken for the black

radium minerals, but the latter do not affect a compass, while magnetite does. Ilmenite is also sometimes strongly enough magnetic to affect a compass, but some specimens are very feebly magnetic.

Pitchblende has been found in silver-cobalt-arsenic veins, as in Joachimsthal, Bohemia, and in quartz veins associated with gold, as in Colorado. These quartz veins are in gneiss and mica schist. They were first worked for gold, but the gold values disappeared where the pitchblende came in. Such veins might be found in parts of Canada where pegmatite dikes are plentiful. These valuable minerals are sparsely scattered in a good many places, just as gold is; and, just as in the case the gold, the exceptional place must be sought where the concentration of the valuable minerals is unusually great. The typical pegmatite dikes may not supply this exceptional concentration. Vein-dikes that are mostly quartz, or those that contain large proportions of calcite, may be more favorable.

Radioactive Waters

Radioactive waters owe the property to radium, radium emanation, or both, picked up by the water in its passage through soil and rocks. Nearly all rocks contain a little radium, there being more in igneous than in sedimentary rocks. As soil is composed largely of the débris of rocks, it also carries a little radium. If the water has only radium emanation dissolved in it, its radioactivity disappears in a few days. If, on the other hand, its activity is due to dissolved radium, the activity is permanent. Most waters show a little temporary activity.

The curative powers of some waters may be due to the radioactive substances dissolved in them. The gases from some mineral springs contain helium, one product of the disintegration of radium. The waters of these springs are likely to be radioactive, as is the case with the waters of the famous hot springs at Bath, England. The curative properties of radioactive waters have been established by experimenting with artificially charged water. The chief curative agent is radium emanation.

URANIUM

Uranium minerals are found mostly in varieties of granite, particularly in pegmatite dikes, quartz porphyry, and other varieties of granite formed in the final stages of the cooling of granite magma. These minerals are also found in vein-like structures associated with granite and in the wall-rocks of the granite and other dikes. (See **Radium** p. 160).

Uranium oxide is used to give a yellow colour to glass. Uranium glass has the peculiar property, **fluorescence.**

Uraninite or pitchblende occurs in a mica mine near Lake Pieds des Monts, about 18 miles north of Murray Bay, in Charlevoix county. At the same locality a carbonaceous material (anthraxolite) was found which, when burned, gave 7.225% of ash containing 35.43% of uranium.

Pitchblende (clèveite) has been found in the Villeneuve mica mine, Villeneuve township, Hull county. The mineral occurs in a coarse pegmatite dike that intrudes garnet-gneiss. One specimen weighing about

a pound was taken out. It was crusted with yellow and red gummite A sample of the pitchblende was found to assay 37.70% of uranium oxide.

Small quantities of pitchblende (uraninite) have been reported from the Leduc mica mine, lot 25, range VII, Wakefield township, Hull county. The rock is pegmatite. A little gummite was also noticed.

Pitchblenede and gummite occur in the feldspar quarry of O'Brien and Fowler on lots 21 and 22, range six of Portland West township, Hull county.

Samarskite and fergusonite occur rather abundantly in a pegmatite dike on Mica Lake, lots 1 and 2, range II, Maisonneuve township, Berthier county. The samarskite contains 10.75% of uranium oxide.

While none of these occurrences of radio-active minerals are of commercial importance, they serve to show the presence of the minerals in the pegmatite dikes of the province. The exceptional quantity and concentration may be found somewhere among the thousands of pegmatite dikes.

A number of mineral springs in Quebec have been tested for radioactivity, and while several are distinctly radioactive, none have been found with such decided activity as the waters of the springs at Bath, England, and other health resorts.

References:

Notes on Radium-bearing Minerals, by Wyatt Malcolm, Geological Survey of Canada, Ottawa, publication No. 1368.

Bulletin No. 16, Mines Branch, Ottawa, The Radioactivity of Some Canadian Mineral Springs, by John Satterly, M.A., D.Sc., and R. T. Elworthy, B.Sc.

METALS OF THE RARE EARTHS

Under this heading are described a number of rare minerals carrying metals the oxides of which are earthy substances. Either the metals or their oxides have been made useful. The minerals carrying them occur in granite and similar rocks, so that there are fair chances of finding workable deposits in Canada.

BERYLLIUM

Beryllium is a very light-metal found in a number of rather rare minerals, the most abundant of which is **beryl,** a silicate of beryllium and aluminum. Precious varieties of this mineral have long been known as emerald and aquamarine. **Chrysoberyl,** mostly green in color, an oxide of beryllium and aluminum; and **phenacite,** usually yellow in color, a silicate of beryllium, may also be of importance in the manufacture of the metal. When not distinctly colored these minerals may not attract attention. Beryl crystals are six sided and look a good deal like quartz crystals, but some greenish shade may be noticeable in the beryl crystals.

The beryllium minerals are found in granite, particularly in the coarsely crystallized variety called pegmatite.

As beryl sells for $60 a ton and upwards, the discovery of an unusually large and concentrated deposit would be very important. Beryl as mined contains only from 3 to 3.5 per cent of the metal beryllium. Chrysoberyl contains theoretically over 7 per cent and phenacite over 16 per cent. The discovery of large masses of chrysoberyl or phenacite would be still more important.

The metal is extracted by a long and difficult process, the last part of which involves decomposition at a very high temperature by an electrical current.

Pure beryllium is a very hard and brittle metal. So far there has been no success in the attempts to roll or draw it. Its very low specific gravity suggests its use as an alloy with other light metals such as aluminum to increase their hardness. The addition of 2 to 2.5 per cent of beryllium to copper or nickel produces alloys with the properties of bronze, but capable of developing great hardness and toughness by heat treatment. Beryllium increases the electrical conductivity of copper castings. The present high cost of beryllium will prevent its use for most of these purposes, but the discovery of more plentiful raw material for its manufacture and improvements in the extraction process may soon bring its price within range.

While none of the beryllium minerals have so far been found in Quebec in sufficient quantities to be economically important, beryl in particular occurs so frequently that the prospect of discovering a workable deposit seems fair. The acid pegmatites, in which beryllium minerals occur, are very plentiful in the Precambrian regions of the Province.

BERTHIER COUNTY

De Maisonneuve Township. Beryl occurs, in some quantity with white mica, tourmaline, and garnet, in a pegmatite dike on lots 1 and 2, range two.

Brassard Township. Beryl crystals are reported from this township.

MASKINONGE COUNTY

Chrysoberyl occurs about a mile below the forks of the Rivière du Poste, a tributary of the Matawin River.

CHICOUTIMI COUNTY

Jonquière Township. Beryl crystals having a diameter of 3 inches and more, and from 12 to 15 inches long have been found in pegmatite dikes in this township.

TEMISKAMINGUE COUNTY

Preissac Township. Beryl occurs frequently with molybdenite in quartz veins and pegmatite dikes in the Kewagama Lake area. It has been observed on the property of the Height of Land Mining Company on the Kewagama River; at the St. Maurice Syndicate mine; and at the southern end of Long Lake, south of Lake Kienawisik Phenacite is found in small quantities associated with beryl, fluorspar, molybdenite, etc., in the pegmatite dikes on the claims of the Height of Land Mining Company.

CERIUM

This metal is present in a number of rare minerals, usually with thorium and sometimes with uranium (See **Thorium** p. 168 and **Uranium** p. 158). **Monazite,** a phosphate of cerium, thorium, etc., is the principal source of cerium products. It is a red, brown or yellowish mineral found in granite and gneiss in scattered

grains. It is hard enough to stand a good deal of wear, and heavy enough to get to the bottom of a body of sand resulting from the breaking down of rock. The source of monazite is the sands in certain parts of North Carolina, U.S.A., which are concentrated by washing. In a glaciated country like Canada the chances of finding such accumulations of monazite are not good, but it should be watched for in panning. Its red or yellow colour attracts attention when it shows in panning for gold. Allanite or cerium epidote is found in pegmatite dikes and other granite structures. Its frequent occurrence in eastern Canada suggests that it may be found in sufficient concentration to be an economic source of cerium products.

Cerium is used in making **ferro-cerium**, the substance that sparks and lights a gas jet when it is rubbed against steel in the well known instruments and toys. Cerium oxide is used as a constituent of gas mantles, etc.

Allanite, or **cerium epidote,** has been found in considerable quantities in Champlain county on the east shore of Lake Bouchard (Lac à Baude). It occurs there in flat crystallizations of a deep brown color, some of the crystals being as much as three inches long and three quarters of an inch thick. The mineral occurs in pegmatite granite, a sample of which weighing 7½ pounds contained 56% of allanite. It has also been found in small crystals in a feldspar rock at Baie St. Paul, Charlevoix county, and in anorthosite at Lake St. John, Chicoutimi county.

Euxenite, Samarskite, and **fergusonite** sometimes contain considerable proportions of cerium. They oc-

cur in pegmatite dikes in the mica deposits of Maisonneuve, Berthier county, and Pied des Monts, Charlevoix county.

Monazite has been found in small quantities in pegmatite at the Villeneuve mica mine, Hull county.

TANTALUM

Tantalum is a rare metal found in a number of rare minerals forming related groups including the **columbite-tantalite** and the **samarskite groups**. They are heavy, black or brown, and most of them when finely powdered are brownish.

Columbite and **tantalite** are minerals that grade into each other according to the percentages of columbic (niobic) and tantalic acids. They may carry important proportions of cerium.

The metal tantalum sells for $6 an ounce. It has been used for making the filaments of electric light bulbs.

Euxenite and fergusonite have been observed in certain mica deposits (See **Cerium**), but only in small quantities. Both contain tantalum.

THORIUM

Thorium is a rare metal that is a constituent of a number of minerals including monazite (See **Cerium** p. 166), thorite, a silicate, and several others. Thorite is usually dull black and brown when finely powdered. It is sometimes orange-yellow and is then called **orangeite** (See **Radioactive Minerals** p. 160). The specific gravity of these varieties ranges from 4.5 to 5.4. They

are accordingly fairly heavy minerals, and are hard enough to stand wear. They may therefore sometimes turn up in panning sand or gravel.

Thoria, as the oxide of thorium is called, is used in making gas mantles. It has the property of giving off an intense white light when heated. (See also **Radioactive Minerals**, p. 159). Minerals containing not less than 6% of thoria sell for $120 a ton.

Thorium minerals have not been found in commercial quantities in Quebec.

The uranium minerals described under **Radium** p. 158 contain more or less thorium.

ZIRCONIUM

Zirconium is a rare metal found in a number of minerals, some of which have already been mentioned (See **Radioactive Minerals** p. 159, **Cerium** p. 166 and **Thorium** p. 168). The principal sources of zirconium products are monazite and zircon. **Zircon** is a silicate of zirconium. It is reddish brown, brownish yellow, pale yellow, yellowish green, gray or white in color. It is harder than quartz, and, being fairly heavy, it is apt to collect in the sand and gravel formed by the disintegration of rocks in which it is found. It occurs in pegmatite dikes and other syenite, nepheline-syenite, and granite structures, and sometimes in crystalline limestone, schists, and gneiss. Concentrates containing 95 per cent of zircon sell for $60 a ton. **Zirconia**, the oxide of zirconium, is used in the manufacture of incandescent gas mantles. Zirconia, like thoria, has the property of giving off an intense white light when

heated. There is a refractory named **zirkite,** made from zirconia. It sells for $50 to $100 a ton.

Zircon occurs in Grenville township, Argenteuil county, lot 10, range V. The mineral is found as reddish brown crystals, sometimes half an inch in diameter.

In Hull county, zircon is sometimes found in the apatite deposits of Buckingham, Hull, Templeton, Portland West, and Wakefield townships.

Small crystals of zircon have been observed in granite dikes in gneiss, on the North River,, St. Jerome, Terrebonne county.

It occurs with white mica at the mica mine 18 miles north of Murray Bay, Saguenay county.

These occurrences of zircon are not of commercial importance.

CHAPTER X

NON-METALLIC MINERALS

CORUNDUM, GARNET, SILICA

CORUNDUM

This mineral is crystallized oxide of aluminum. The crystals when well-formed can be seen to be six-sided prisms. Next to diamond, corundum is the hardest of minerals. In an impure form it has long been used as emery for abrasive purposes. The pure corundum is superior to emery for these uses.

Uses. The principal use is an abrasive, that is, for grinding and polishing. For these purposes it is made in wheels, whetstones, abrasive paper and cloth; but the loose grain or powder is used for polishing, etc. **Carborundum,** a name having a flattering resemblance to **corundum,** is a compound of carbon and silicon made in electric furnaces (omitting details) by fusing the cheap materials coke and silica sand or some other form of silica. Artificial corundum is another competitor, made by the long-continued action of electrical heat on bauxite, which is oxide of aluminum combined with water. By putting it through a chemical process

and heating the product, pure oxide of aluminum is obtained. It has no cutting power because it is not crystallized. When heated in an electrical furnace, it crystallizes, and the product is entitled to the name corundum. Both the natural and the artificial are crystallized oxide of aluminum. Artificial corundum is in the market under the name **alundum.**

The only reported occurrence of corundum in the province is in some of the gold-bearing gravels of the Eastern Townships. It may be found in the extensive areas of anorthosite north of the St. Lawrence.

GARNET

The garnet family includes a number of minerals similar in composition and alike in their crystal forms. They are all silicates, and most of them have also the oxide of aluminum as part of their composition. The common commercial garnet, **almandite,** is silicate of aluminum and iron. The crystals of garnet are in the cubic system, and this gives them a tendency to take on forms that appear in the rock as nodules, and as garnet weathers more slowly than the other minerals forming the rocks in which they are found, these nodules or grains are apt to stand out from the surface. The color of the common garnet is red or brown, but there are black, green, yellow, and white varieties. The hardness varies from 6.5 to 7.5, using the scale in which the hardness of quartz is 7.

Garnets occur in a great variety of rocks, but garnet- gneiss and garnet-schists are the principal sources

of commercial garnet. These are very plentiful in Quebec, but the requirements of a commercial deposit are so exacting that very few are found to fulfil them. The crystals must not be too small, not less than pea size. They must break so as to give grains with good cutting edges. The hardness must be the maximum for garnets. Pink or red color is preferred by the trade, although the best qualities may be found in garnets of other colors. The amount of garnet in the rock should not be less than 10%.

Apart from their use as jewels (see **Precious** and **Semi-precious Stones** p. 288) the greater part of the garnet produced is used in the manufacture of garnet-coated papers and cloths, a little being used in the loose condition for polishing, for sand blast, for finishing plate glass, and similar purposes. Garnet-coated paper and cloth are used extensively in wood-working and leather industries.

Garnet concentrates sell for about $85 a ton. The concentration is effected by the usual gravitation methods, which are suitable for garnet as it is heavier than most of the minerals with which it is found. Magnetic separation may be required to remove magnetite, etc. Hornblende, which is fairly high in iron, can also be removed by magnetic separation.

In the region north of the St. Lawrence River, between Quebec and Montreal, and from 50 to 150 miles from the river, there are a great many bands of garnet-bearing gneiss and quartzite, mostly associated with crystalline limestone. Similar occurrences are to be found farther west, north of the Ottawa River.

Garnet-bearing gneiss is known to exist in many parts of the province far from transportation facilities and therefore of no commercial importance at present. Most of the known deposits are unsuitable for the manufacture of the finer abrasives, but a few are of good quality for this purpose, and doubtless others will be found suitable when tested. Only a few of the better known and more promising deposits are described here.

JOLIETTE COUNTY

Cathcart Township. In the southwest corner of this township and in the adjoining townships of Rawdon, Chertsey, and Kildare, is a zone of garnetiferous gneiss and quartzite associated with crystalline limestone. This zone is traceable for at least a quarter of a mile. In places the rocks average over 30 per cent garnet, the crystals being from ¼ to 1 inch in diameter. About three miles to the east is another series of bands rich in garnet. The garnet is of good quality, the deposits cover several square miles, and some of the bands carry a high percentage of garnet.

De Ramsay Seigniory. Near St. Jean de Matha and also near St. Pierre, there are numerous bands of garnetiferous gneiss, in some of which the garnets are from pea-size to cherry-size. One band contains large garnets up to three inches in diameter. Another, 30 feet wide, carries about 25 per cent of deep red, well-formed garnets, probably suitable for abrasive purposes.

LABELLE COUNTY

Joly Township. Garnetiferous gneiss interbanded with veins of pyrrhotite and massive crystalline gar-

net occurs two miles south of Labelle station on the Montreal-Mont Laurier branch of the Canadian Pacific railway. In places the garnets and pyrrhotite are mixed. Four parallel bands 50, 70, and 200 feet apart are exposed. For several yards on either side of the garnet-pyrrhotite bands, the gneiss contains a high percentage of small garnets. The garnet is the almandite variety, from a dark red color to nearly black when viewed in large pieces. This garnet is of the highest quality for abrasive purposes. The deposits have been explored and developed, and a considerable tonnage is apparent.

MONTCALM COUNTY

Rawdon Township. At Darwin Rapids and Falls, there are bands of garnet-gneiss and quartzite, forming a zone about 150 feet wide. Some of the bands, 5 or 6 feet wide, contain up to 30 per cent of garnets. The garnets are rather small, rarely larger than pea-size, but a few narrow bands show crystals almost an inch across. These are, however, much shattered.

ABITIBI COUNTY

Baudin Township. In a cutting three and a quarter miles east of Langlade station on the Quebec-Cochrane line of the Canadian National railway, there are bands of gneiss containing a high percentage of garnet of cherry-size. In one place the rock is probably 40 per cent garnet. This deposit has fair possibilities of economic usefulness.

Reference: Abrasives, Part III, Garnet, by V. L. Eardley-Wilmot, Mines Branch, Ottawa, publication No. 677, p. 19.

SILICA

Silica is the material of which quartz is composed. It is the oxide of an element named **silicon,** present in pig iron and steel. In the blast furnace the silicon has been reduced from the silica mixed with the iron ore. Silicon is also a component of **ferrosilicon.** In nature, it is always the oxide, silica, or some compound of it, a **silicate,** that occurs. Quartz is the common crystallized form of silica. There are other forms such as chalcedony, flint, etc., that are not obviously crystalline. In addition to silica, opal contains a little water. For information about some varieties of silica, See **Precious and Semi-precious Stones** p. 290.

The varieties of silica of importance economically are vein or dike quartz, flint, sand, sandstone, quartzite, diatomite or tripolite, rottenstone, and tripoli.

Quartz

As vein material and a constituent of various rocks, quartz makes up about 12% of the earth's solid crust. When pure it is colorless and usually opaque in considerable masses but translucent or transparent in small grains. It is often colored by impurities.

While quartz is a constituent of acid rocks such as granite, mica schist, and granite-gneiss, it cannot be economically concentrated from these rocks. A common source of quartz is pegmatite dikes in which large masses of the mineral are found unmixed with feldspar or mica. Quartz is sometimes quarried along with feldspar. Another source is the tailings from gold mills. In smelting operations, a low grade siliceous ore

of copper is sometimes mixed with ores having a gangue high in lime and other bases. The quartz helps to form a fusible slag.

Flint

Flint is a kind of silica not obviously crystalline, although the miscroscope shows that it is made up of very small crystals. It is found in some countries as nodules in chalk and limestone. Impure flint is often called **chert**.

Sand

When granite and other rocks containing quartz disintegrate, the grains of quartz, being harder and less liable to decomposition than other minerals, endure longer during the process of weathering and washing down into hollows. It thus comes about that beds of sand are composed largely of grains of quartz. The name **silica sand** is used for beds that are free or nearly free from other minerals. Such sand has the advantage of being already in a state of fine division, so that the expense of crushing is saved.

Sandstone

This is a rock composed of grains of sand more or less water-worn, and cemented together by silica, calcite, limonite, or sometimes by a little clay that has been mixed with the bed of sand from which the stone has been formed. The grains of quartz vary in size in different sandstones, and the cementing is more or less effective. The sand may have been white silica sand, or it may have been more or less mixed with

other minerals. The cementing material may be white or may have some color. These varying circumstances have influenced the appearance, texture, and composition of the sandstone.

Quartzite

Quartzite is a rock formed from sandstone by the influence of heat, pressure and the action of materials from the hot masses of rock matter that have invaded the region. The grains of quartz are more completely cemented by the filling up of inter-spaces with silica, the other minerals mixed with the quartz may have been re-combined and crystallized so as to form mica, etc., and these changes may have gone so far that nothing of the original granular structure of the sandstone is visible to the unaided eye. Quartzite sometimes looks very much like vein quartz.

Diatomite

Also called **infusorial earth, diatomaceous earth, kieselguhr**, and **tripolite**. It is a deposit made up of the silica skeletons of minute plants called **diatoms,** that grow in both fresh and salt water. The deposition is going on constantly in favorable places, as in quiet shallow lakes. Accumulations of past ages are sometimes found as a soft rock, as in the immense deposit in California. More recent deposits are occasionally found in old lake bottoms where some change in levels has caused the water to drain off. The mud at the bottoms of some existing lakes consists of this material.

Diatomite is not likely to be found in the consolidated state in a country that has been severely gla-

ciated; but deposits formed since the Great Ice Age are possible. To be of economic importance a diatomite deposit must be large, easily accessible, and free from clay and other impurities.

Rottenstone and Tripoli

These are siliceous materials left by the weathering of siliceous limestone, etc. Rottenstone is a soft, porous, rusty rock, used for polishing furniture, celluloid, and plate glass. Tripoli looks a good deal like diatomite, but the microscope fails to show the diatom structure. Glaciation has made it unlikely that such soft surface materials, requiring ages for their accumulation, will be found in most parts of Canada.

INDUSTRIAL USES OF SILICA

Whatever its source or natural form, pure silica is the same substance. Differences in the natural materials, such as vein quartz, sandstone, quartzite, and sand are due to their state of division, and to other substances mixed with the silica. Diatomite comes near opal in its composition, and is a little softer than crystallized quartz. It is also very porous. When silica is required for fluxing in smelting operations, for example, the requirements are that it shall be cheap, as nearly pure as possible, and of a suitable size for furnace operations. These conditions being fulfilled, the origin of the silica, whether vein quartz, sandstone, or quartzite, is not important. But if the silica is to be used in a finer state of division, the shape and size of the grains must be considered. Natural sand is not suitable material for making silica

bricks, even if its analysis shows that it has the same composition as ground quartzite that makes good bricks.

In the industries, silica is used as **lump silica, silica sand,** and **ground silica.** These are commercial terms indicating certain sizes of pieces or grains, lump silica being the largest and ground silica the smallest.

Uses of Lump Silica

This product is obtained as vein quartz, sandstone, or quartzite. It may be used as quarried, but for some purposes it is crushed and sized. In any case it commands a low price only.

Ferrosilicon is made in an electric furnace (1) by the reduction of silica and iron ore with carbon or (2) by the reduction of silica, the iron being added as turnings. The silica may be high grade quartzite or may be in the form of a highly siliceous iron ore. The most objectionable impurities are phosphorus and arsenic which lead to the generation of very poisonous gases when stored ferrosilicon is acted on by the moisture of the air. Lime and magnesia should not exceed 0.20% each. The quartzite should analyze 97½ of silica or more. Ferrosilicon is used in the manufacture of steel.

Use as a Flux. In the smelting of copper ores that have a basic gangue, silica may be required as a flux. Another copper ore with a silica gangue is the most economical source of silica. The silica is required to form a fusible slag with the oxide of iron and other basic materials in the ores.

Other uses. In the manufacture of phosphorus from bone ash and apatite, silica is used to flux off the lime. Very pure silica from feldspar quarries has been used for this purpose.

Blocks of vein quartz and quartzite are used in certain chemical industries where acid gases are passed through towers to dissolve in water trickling over the quartz.

On account of their great hardness pebbles of flint or quartzite are used in rotating mills for fine grinding of ores, etc. The linings of these mills are also commonly made of the same materials.

Uses of Silica Sand

The sand may be either natural shore sand, or ground sandstone or quartzite.

Silica Brick is essentially grains of silica cemented by a little lime. The bricks will stand a very high temperature, and are used for lining metallurgical and other furnaces. The silica used is quartzite crushed to a small size. **Gannister** is a siliceous rock containing enough highly refractory clay to act as a bond. (**Refractory** materials are those that will stand a high temperature without melting and also resist the chemical attack of the materials charged into the furnace.) Quartzite is preferable to vein quartz, sand or sandstone, and it must be very high in silica, say 98% or more.

Glass Sand. Ordinary glass requires 50 to 75% of silica for its manufacture. Pure white silica sand is commonly used. It must be free from iron, alumina, magnesia, lime, and alkalies. The absence of lime and

alkalies (potash and soda) is desirable, although both are used as part of the charge. If they are present in the sand, they have to be allowed for, and that is troublesome. Crushed sandstone, quartzite, and vein quartz may be used, but the natural glass sand can be got so cheap that it rarely pays to use the other materials.

Manufacture of Carborundum. This abrasive is a compound of carbon and silicon. Silica is the oxide of silicon, and silica sand is one of the raw materials used in the manufacture of carborundum. It is charged into electrical furnaces with coke, sawdust, and salt. The sand must be at least 99.25% silica, and must be free from lime, phosphorus, and magnesia.

Steel Foundry Sand. Sand for the moulds in steel foundries is carefully selected for refractoriness, bonding power, and permeability to gases.

Silica Sand for Furnace Linings. Natural sand or crushed quartzite is used to line Bessemer converters, for the hearths of reverberatory furnaces for matte smelting, and to line electric furnaces for melting scrap iron. The material should be 95% silica or over, and should be of even grain.

Fused Silica Ware. The high fusion point of pure silica made it impossible to construct ware of this material until the electric furnace came into use. In these the silica is packed around a perforated carbon tube through which air can be forced to blow the softened silica out until it fits the mould. Fused silica ware is highly refractory, very strong, and can be heated and cooled suddenly without cracking. Ma-

terial of the quality of glass sand is required for its manufacture.

Minor Uses of Silica Sand. There are a number of smaller uses, such as the manufacture of sand paper and other abrasive and polishing apparatus. For these purposes crushed quartzite or vein quartz has a better grain than crushed sandstone or natural sand.

Uses of Powdered Silica

Under this head are included all silica materials ground to a fine powder, too small to be classed as sand. It is made from flint, vein quartz, quartzite, or sandstone.

Powdered Silica in Pottery. It is used to the amount of 35% in the bodies and also in the glaze of table ware, sanitary ware, floor tiles, etc. The iron content should not exceed 0.32%. Ground silica is used in metal enamelling.

Powdered Silica in Paint. The finest powdered silica is now a standard material in paint. It must be free from color. It increases the durability of the paint.

Sodium Silicate. This material, also called **water glass** or **soluble glass,** contains about 79% silica. It is made by fusing powdered quartz with sodium carbonate or sodium sulphate. Another way is to heat silica under pressure with a solution of caustic soda. For this method, diatomite is preferred, as it dissolves more easily than other forms of silica.

Other Uses. Powdered silica is used in the manufacture of asbestos shingles, as a filler and scourer in hand soaps, in dental work, and for a number of other small uses.

Uses of Diatomite

The three largest uses are as an abrasive, as a heat insulator, and as a filter and decoloriser. As an abrasive it owes its usefulness to its hardness and to the sharpness of the grains. Its insulating power depends on its porosity, which also doubtless aids its usefulness as a filter. Other uses are the manufacture of sodium silicate, as a filler for rubber, sealing wax, phonograph records, and other manufactures requiring a cheap inert material. A new use of growing importance is to mix with concrete. It fills the spaces and makes a uniform mixture with less water.

The sources of silica in Quebec for industrial purposes are sandstone, quartzite, vein quartz, quartz sand, and diatomite.

SANDSTONE

Southwestern Quebec

Potsdam sandstone underlies considerable portions of southwestern Quebec, including large areas both north and south of the St. Lawrence River immediately west of the Island of Montreal, and others north of Lake of Two Mountains. A narrow band of Potsdam sandstone lies on the north side of the Ottawa River from a point on the Gatineau River a few miles north of Ottawa eastward along the general route of the Canadian Pacific railway. On the south side of the St. Lawrence below Quebec city, there are a number of sandstone areas (also classified as quartzite, see p. 186) in Montmagny, L'Islet, and Kamouraska counties, including the Pilgrim Islands, three or four miles off shore from St. André in Kamouraska county.

For industrial purposes, sandstone must not only be of the right quality, but it must be easily quarried, and near railway or water transportation. The greater part of the large area of sandstone in **Huntingdon** county is too far away from the railways to be at present available, but the New York Central railway comes within about two miles of the western edge of the sandstone where it crosses the international boundary.

Two Canadian National lines cross the area in **Chateauguay** county, and the northward prolongation of this area forms the shore of the St. Lawrence River from Beauharnois to a point two miles below Melocheville.

The whole of **Ile Perrot** at the mouth of the Ottawa is underlain by sandstone.

Both shores of the **Ottawa River** are sandstone from Ile Perrot to Carillon, and the large sandstone area that forms the angle between the Ottawa and the St. Lawrence is crossed by three lines of railway.

North of **Lake of Two Mountains,** the shore is bordered by sandstone which is crossed by the Canadian National railway still farther north. This area wings out to the west and north east. The western wing is followed by the Canadian Pacific railway from Ste. Scholastique to Mabel, a station about 6 miles west of Lachute.

Parts of the narrow band along the **North Shore** line of the Canadian Pacific railway, are on the railway line, or on the river, and most of it is within easy reach of railway or river.

A sandstone area about 4 miles long just north of the international boundary in **Missisquoi** county is skirted by the Central Vermont line of the Canadian National railway.

It is seen from the foregoing description that there are in the province vast quantities of sandstone conveniently situated for transportation. Analysis of samples has shown that the quality of the sandstone at a number of points is suitable for such manufactures as ferro-silicon, glass, silica brick, and other products. Quarries have been operated near Beauharnois and Melocheville on the south side of the St. Lawrence, and at Cascades Point on the north side. North of the Ottawa River, sandstone is quarried at St. Canute on the Canadian National railway. In the Buckingham area, sandstone forms a prominent-ridge, convenient for quarrying, near East Templeton on the North Shore line of the Canadian Pacific railway.

QUARTZITE

KAMOURASKA

Quartzite has been formed from sandstone by changes that have resulted in more or less recrystallization of the quartz, and addition of silica and minor constituents of the rock, and sometimes other materials. These changes may have gone so far as to conceal the original characteristics of the rock so that it resembles vein quartz. On the other hand, the change may be so slight that the rock might be classified either as sandstone or quartzite. Grenville quartzite, the oldest example of this rock, is usually very completely altered. The quartzites of later ages show vari-

ous degrees of alteration. The sand-stones of the Cambrian period are sometimes so changed that it becomes a question whether they should not be classified as quartzites. This seems to be the case with the areas of these rocks scattered along the south shore of the St. Lawrence River, from Quebec City eastward. The quartzite in this region forms hills that afford good opportunities for quarry faces. The quartzite is fine and even-grained and weathers almost white. The best grade of rock is to be found in the northeastern part of the area, near St. Pascal and St. André.

The Pilgrim Islands, near St. André, are masses of quartzite. The situation of these islands gives them the advantage of water transportation for quarry products. Analysis of samples shows the quartzite to contains from 95.40 to 98.86% of silica, and a quarter of one per cent or less, of iron oxide. It is also low in lime. In other respects the quartzite of these islands seems to be of good quality.

Near **St. Pascal** station on the Canadian National railway there are a number of quartzite ridges convenient for quarrying. The rock is not so high in silica as that of the Pigrim Islands, and it is higher in iron oxide and lime.

The availability of the Kamouraska and other quartzite deposits in the district depends largely on cost of transportation to industrial centres. The Pilgrim Islands are well situated in this respect, as the material can be carried by water. The quartzite on the mainland is mostly too far from the shore for this, and transportation must necessarily be by rail.

NOTRE DAMES DES ANGES

Quartzite of Grenville age forms ridges in the townships of Chavigny and Montauban. A number of these deposits are within a half mile from the Canadian National railway near Notre Dame des Anges station. Bands of mica schist in places are so well defined that they can be cobbed out or avoided. Some of the quartzite is on the banks of the Batiscan River that skirts the railway line east of Notre Dame des Anges station. Analyses show that the quartzite is suitable for the manufacture of ferrosilicon.

AMHERST TOWNSHIP

White quartzite carrying 5 to 12 per cent of kaolin occurs on the property of the Canadian China Clay Company, at St. Remi d'Amherst, Amherst township. Labelle county. When crushed and washed, this quartzite forms a sand containing over 99 per cent of silica. The product is suitable for making silica bricks.

VEIN QUARTZ

Under this heading are included quartz found in veins and also the quartz masses often occurring in pegmatite dikes. Quartz veins carrying gold and other metallic minerals have sometimes been used in smelting operations to mix with ore having a basic gangue. The mining of a barren quartz vein with quartz as the only product is usually not commercially feasible, unless the mass of quartz is so large as to admit of quarrying.

Quartz is produced as a by-product in some of the feldspar quarries in the Lièvre River district. Quartz

from this source has been used as a flux in the manufacture of phosphorus at Buckingham by the Electric Reduction Company.

SAND

Builder's sand is plentiful at Oka on the Lake of Two Mountains, and in many other localities. "Silica sand" is a name applied to sand composed almost altogether of grains of quartz. This has so far been found only in small quantities. Common sand is usually too high in iron and other impurities to be used for industrial purposes other than the manufacture of mortar, concrete etc.

Small deposits of white sand of good quality are reported in Franklin and Havelock townships, Huntingdon county, but the quantity is too small to be commercially important.

DIATOMITE

The known diatomite deposits in Quebec are all recent and lying at the bottoms of lakes and swamps. Most of them are too small or too impure to be of importance commercially.

The deposit near Lake Simon, Colbert township, Portneuf county, is at the bottom of a pond and swamp near the Canadian National railway about 3 miles west of Allen's Mills station. It is about two acres in extent and from 4 to 6 feet thick. The diatomite is of good quality, and is very close to railway transportation.

There is a deposit in Chertsey township, in Lake Michel, 3 miles north of St. Theodore. The lake drains

into the Ouareau River. The deposit covers about 4 acres under a swamp on both sides of the outlet of the lake. The depth of the diatomite is from one to one and a half feet. It is light gray in color and burns to a pale brick-red. Material from this deposit was used by the Department of Public Works, Ottawa, in making tests on the use of diatomite in concrete.

In Wexford township, ,Terrebonne County, there is a diatomite deposit covering about 4 acres of the bottom of Castor Lake to a depth of several feet.

References: Silica in Canada by L. Heber Cole, Mines Branch, Ottawa, publication No. 555.

Diatomite, by V. L. Eardley-Wilmot, Mines Branch, Ottawa, publication No. 691.

CHAPTER XI

NON-METALLICS (Cont'd.)

CRYOLITE, FELDSPAR, FLUORSPAR, ANDALUSITE

CRYOLITE

While a cryolite deposit has not so far been discovered in Quebec, the mineral is so important in the manufacture of aluminum and various enamels, etc., that some mention should be made of it, especially as the geological conditions of large parts of Quebec are favorable to its occurrence. It is a mineral of rather unusual composition, fluoride of sodium and aluminum. It owes its value to its easy fusibility and to its power of causing the fusion of more refractory substances. It is a white mineral, although sometimes colored by impurities. It looks somewhat like quartz but is a good deal softer. There is only one workable deposit known in the world, at Ivigtut in Greenland, where it is found as a vein or dike in gneiss. Small quantities have been found in other places in pegmatite dikes, and the Greenland cryolite may be looked upon as a freak pegmatite dike in which everything

was left out but the cryolite. Considering the abundance of pegmatite dikes in the granite and gneiss regions of Quebec, the chances should be good for finding the second cryolite vein to help supply the world's demand. Prospectors should acquaint themselves with the mineral, so as to recognize it, if they should happen upon it. The Ungava peninsula offers a wide field for exploration. The discovery of a workable vein of cryolite in eastern Canada would be of major importance.

FELDSPAR

This name is applied to a family of minerals which are alike in being all composed in part of silica and aluminum oxide. They are all **silicates of aluminum** with either **potash, soda,** or **lime.** So there are **potash feldspars, soda feldspars,** and **lime feldspars.** Most feldspars are of an intermediate composition. For example, the commonest commercial feldspar is a potash feldspar called **microcline,** which generally has from 2 to 4% of soda in place of part of the potash. Another common potash feldspar is **orthoclase,** the most plentiful feldspar of ordinary granite. **Albite** is a soda feldspar, common in granite and syenite. **Labradorite** is a lime feldspar.

In the manufacture of pottery and similar industries, feldspar is used both as an ingredient of the clay or other body and as a glaze for the finished products. For the latter purpose especially, the fusion temperature must be as low as possible, and this property is best in a potash feldspar containing a few per cent

of soda. Feldspar of this composition has also the property of not shrinking too much on cooling.

Commercial feldspar is found in a variety of granite called **pegmatite,** characterized by the large size and irregular distribution of the crystals of feldspar, quartz, and mica. This rock is largely in the form of **dikes,** that is, masses that have a great length in proportion to their width and that have broken their way through other rocks from below so as to form a rock mass approaching the vertical in position. Pegmatite dikes show a great variety in size and composition, and it is only the exceptional one that is suitable as a source of commercial feldspar. The feldspar must be in masses large enough and pure enough to permit it to be quarried without much hand sorting. Certain dark colored minerals such as tourmaline and hornblende must be absent, and very little quartz is permissible for the best grade feldspar. The market price is so small, \$5 to \$8 a ton, that no great length of haul to railway or water transportation can be borne. These requirements rule out the great majority of the thousands of pegmatite dikes known in Quebec.

Uses. The greater part of the feldspar is used in the manufacture of pottery, partly to mix with clay and partly to glaze the dishes. The amount of feldspar used in the body of the dish may be as much as 36%. The glaze is made of feldspar mixed with clay, etc. in such proportions as to melt at a lower temperature than the softening point of the dish. Feldspar is the chief ingredient in enamels for iron ware. It is also used in making opalescent glass, and other special kinds of glass. For making artificial teeth feldspar of

especially high grade is used, and the requirements for "dental spar" are so exacting that the price is about four times that of ordinary No. 1 "spar." Other uses are in abrasive soaps, as a binder in making corundum and other wheels, for floor and wall tiles, and in paints. Crude feldspar of lower grades is used for stucco-dash and roofing, and for chicken grit. Much experimenting has been done to find some profitable method of extracting the potash from feldspar, but so far without commercial success. To render the potash soluble for plant food, C.W. Drury fuses feldspar with iron ore to form a slag in which the potash is so easily soluble that it should serve the purpose of a plant food. More elaborate proposed methods separate the three constituents, potash, alumina (oxide of aluminum), and silica, all of which are useful.

FELDSPAR IN QUEBEC

The greater part of the province of Quebec forms part of the Precambrian Shield, and throughout the Precambrian regions there are areas of granite and syenite more or less of which has the coarse pegmatite characteristics favorable to the occurrence of bodies of merchantable feldspar. While pegmatite dikes are very numerous, only a small proportion of them are workable for feldspar, and many of these are too far from transportation to be at present available. The principal market is the United States, and the prices paid for feldspar — \$5 to \$10 a ton, — are too small to permit of a long railway haul. These considerations rule out all but the best deposits and even

among these admit only those near railway lines or water routes.

Buckingham Area

This area includes the valley of the Lièvre River, and to some extent that of the Gatineau. The area lies north of the Ottawa River, in Ottawa county, now divided into Hull and Labelle counties. The feldspar mined is usually microcline, but some quarries have yielded orthoclase, and white albite has been mined for the manufacture of scouring soaps. Muscovite mica and quartz have been produced along with feldspar in some of the quarries. The chief activity of late years has been in the north of Buckingham township, the southern part of Derry township, and in the township of Portland West, all traversed by the Lièvre River which provided water transportation to Buckingham village, the railway shipping point.

AYLWIN TOWNSHIP

The McArthur mine is on lots 47 and 48, range eight, where a deposit of albite feldspar is mined for use in the manufacture of scouring soap and powder.

BUCKINGHAM TOWNSHIP

Both feldspar and quartz have been produced from quarries on lot 14, range twelve, about 3 miles east of the Lièvre River, and 9 miles north of Buckingham village, the nearest railway shipping point. The quarries have been opened in a pegmatite dike about 150 feet wide that follows a ridge of Grenville gneiss across several lots. The feldspar is pink-gray orthoclase high in potash, from 13 to 14 per cent. It is ac-

companied by quartz that can be taken out relatively pure, and by muscovite of rather poor quality.

A quarry has been worked on lots 27 and 28, range nine, by Wm. and J. J. Cameron, of Buckingham.

DERRY TOWNSHIP

The quarries of O'Brien and Fowler have been the largest producers in this township. There is a quarry on lots 7 and 8, range one, and another on lot 15 of the same range, the first is about a mile and a half, and the second about 3 miles, from a wharf on the Lièvre River.

Shipments have recently been made from a feldspar quarry on lots 9, 10, and 11, range two, operated by Wm. and J. J. Cameron, of Buckingham, and from a quarry on lot 2, range one, by Alfred Parcher, of Glen Almond. Another property recently active is that of Em. Lapointe, on lot 1, range five.

HULL TOWNSHIP

Feldspar has been quarried at several points in this township. On lot 13, range nine, is a rather narrow body of feldspar a large proportion of which is high-grade. It is a light-brown or grayish microcline. This deposit is conveniently situated for transportation, being 2 miles from Chelsea station on the Gatineau line of the Canadian Pacific railway.

PORTLAND EAST TOWNSHIP

White microcline of dental spar quality has been taken out in large quantities from a quarry on lots 31 and 32, range nine. The property is 22 miles from Buckingham, and only the high-priced "dental spar" can stand such a long haul to a shipping point.

PORTLAND WEST TOWNSHIP

Dental spar has been produced from a quarry on lots 21 and 22, range six, the property of O'Brien and Fowler. The quarry is on a high hill near Harper Lake, about 7 miles west of the Lièvre River. The pegmatite consists of large crystals of white albite and pink microcline, with some quartz and muscovite. There is also a little black tourmaline and garnet Pitchblende and gummite are present in small quantities. The feldspar can be readily taken out in large, clean pieces. The microcline is of the right quality for dental spar.

On lots 2 and 3, range five, is a quarry operated by Em. Lapointe. Feldspar has been shipped from this property in recent years.

Both dental spar and ceramic feldspar have been recently shipped from the quarry of Bush Winning on lot 17, range six, and lot 25, range seven.

TEMPLETON TOWNSHIP

Templeton township lies north of the Ottawa River, which forms its southern boundary. The north shore line of the Canadian Pacific railway crosses the township. About half a mile from East-Templeton station is a feldspar quarry on lot 14, range two. The feldspar is pink orthoclase. It is mixed with quartz in veinlets and splashes. Hornblende occurs in places rather plentifully.

On the north half of lot 26, range eight, is the Langill or Allan quarry, from which a good deal of feldspar has been taken. The quarry is in the face of a steep ridge, the whole face of the hill being compos-

ed of red microcline with small splashes and bunches of quartz which forms only a small proportion of the mass. There are no harmuful accessory minerals in more than small amounts. The property is 7 miles from Gatineau station on the north shore line of the Canadian Pacific railway.

VILLENEUVE TOWNSHIP

This township is north of Derry township. Its western boundary is the Lièvre River. On lot 34, range one, is the Villeneuve Mine, opened in 1884 for mica, feldspar being at first produced as a by-product. The mine is in a large pegmatite dike, 3 miles east of the Lièvre River, and 20 miles north of Buckingham. The dike is 150 feet wide, and consists of white feldspar of the albite and microcline varieties, mixed with quartz in which muscovite crystals are embedded. Black tourmaline is abundant. A good deal of the feldspar can be taken out clean, the quantity available is very large, and some of it is of "dental spar" quality. The greenish variety of microcline feldspar called amazonstone occurs, and very fine examples of the beautiful iridescent peristerite variety of albite are met with. This deposit is remarkable for the number of rare minerals found in it, including pitchblende, zircon, cerite, and monazite.

WAKEFIELD TOWNSHIP

The Leduc quarry is on the east half of lot 25, range seven. The deposit is a pegmatite dike about 40 feet wide, composed of white and smoky quartz, cream-colored microcline feldspar, and grayish lithium mica (lepidolite). In the feldspar there are sometimes large

crystals of the greenish variety called amazonstone. Green, black, and pink crystals of tourmaline penetrate the masses of feldspar and quartz. Some of the tourmaline is possibly of gem quality. Small quantities of pitchblende and gummite occur in the dike, and also the lithium mineral, spodumene.

Pontiac County

A small deposit of feldspar occurs on lot 30, range two, Waltham township, 2½ miles from the Canadian Pacific railway. The southern boundary of Waltham township is the Ottawa River, at Allumette Island.

Berthier County

The Maisonneuve mine is on lots 1 and 2, range two, Maisonneuve township. It is 40 miles from the nearest shipping point, Ste. Emélie station on the Canadian Northern Quebec railway. Both the distance from transportation and the intimate mixture of quartz with the feldspar would prevent the exploiting of this deposit. The rare minerals beryl and samarskite occur in this dike.

Charlevoix County

In Lacoste township, about 18 miles from Murray Bay, is a body of pegmatite that was formerly developed as a muscovite mica mine. The feldspar is mixed with quartz, but considerable quantities of the pure mineral could be cobbed out. But the distance to the nearest shipping point, 18 miles to Murray Bay, makes it impossible to work the deposit profitably. The

rare radium mineral, cleveite, is found in the dike, and also the carbonaceous mineral, anthraxolite, the ash of which carries over 35 per cent of uranium oxide.

Saguenay County

BERGERONNES TOWNSHIP

Pegmatite dikes have been developed for muscovite mica in this and adjoining townships, but they are too remote from transportation to permit of profitable operation for feldspar.

Lower St. Lawrence

QUETACHU OR BIG BAY

This bay is about 500 miles below Quebec City. There is a large deposit of feldspar on the Manicouagan peninsula, on the east side of the bay, but attempts to develop it have so far been unsuccessful. The deposit is composed of microcline feldspar and quartz, in places intergrown as graphic granite. But large crystals of pure feldspar up to 18 inches long are frequent, and there are zones of the dike that will average less than 10 per cent of quartz. Black mica. tourmaline, and garnets are frequent enough in places to lower the grade of the feldspar. Of these impurities black mica is the most frequent. The dike is about 750 feet wide, of which 200 feet is possible feldspar. The quantity of feldspar is very large.

There is also a very large deposit of feldspar on the west side of Big Bay. The quantity of pure white graphic granite is enormous. Garnets rich in iron are

pretty uniformly sprinkled through the graphic granite. They could be removed from the crushed material by magnetic separation. The graphic granite is an intergrowth of pure white microcline feldspar with variable amounts of white mica, tourmaline, and garnets. The western feldspar deposits form three ridges terminating in a peninsula. The eastern and western ridges are largely graphic granite, but in the middle ridge there are large masses of pink orthoclase feldspar with crystals up to 12 inches across mixed with coarse quartz and very little white mica. There are no garnets in these masses.

These feldspar deposits resemble those of the Buckingham area in being closely associated with schists, quartzite, and crystalline limestone of the Grenville series.

References: Feldspar in Canada, by Hugh S. de Schmid, Mines Branch, Ottawa, publication No. 401.

Report on The Feldspar Deposits of Quetachou-Manicouagan Bay, Que., by W. Erlenborn, M.Sc., Bureau of Mines, Quebec, 1924.

FLUORSPAR

Also called **Fluorite**. Fluorspar is commonly white, but often shows shades of green, blue, and purple. It is harder than **calcite**, being of standard hardness 4, while that of calcite is 3. It is found in veins, and is fairly common as a constituent of metal ore veins. It is only exceptionally that the vein-filling consists of fluorspar exclusively or almost so. For commercial

purposes a fluorspar vein must have very little of the sulphur minerals such as pyrite and barite, and the proportion of silica must be low. The composition of fluorspar is **calcium fluoride. Calcium** is a metal of which lime is the oxide. **Fluorine** is a gas closely related to chlorine.

Uses. Fluorspar is used largely as a flux in the manufacture of open hearth steel. For iron and steel making fluorspar must be at least 80% calcium fluoride and must be free from sulphides, sulphates, and phosphates. For the "acid" steel process the requirements are still more rigid, namely, not less than 98% calcium fluoride, not more than 1% silica and freedom from sulphur and phosphorus.

Fluorspar is used in the manufacture of glass and enamels, and as a bond in making emery wheels and carbon electrodes. It is the raw material for the manufacture of hydrofluoric acid used to etch glass and for other purposes. Fluorspar is the starting point in the manufacture of important materials used with cryolite in the reduction of aluminum. Very perfect colourless crystals are in demand as "optical spar" for the manufacture of certain optical instruments. For such exceptional crystals a high price is paid.

FLUORSPAR IN QUEBEC

The frequent occurrence of fluorspar as one of the vein minerals of deposits of apatite, barite, etc., in rocks of the Grenville series north of the Ottawa River shows that the conditions for the deposition of this mineral existed throughout a large area. While no commercial deposits have so far been found, further

search may reveal important concentrations of fluorspar, similar to those of the Madoc region in Ontario. Some of the known occurrences are mentioned at page 276. Green fluorspar occurs in considerable proportion in calcite veins with galena at Baie St. Paul and Murray Bay. These veins cut the Potsdam sandstone of that region, and are therefore not older than the Cambrian rocks. The Ontario fluorspar veins cut Ordovician limestone.—In Hull and Labelle counties, fluorite is frequently met with in the apatite and mica deposits. Green fluorspar occurs in a barite vein in Hull township, lot 7, concession X, and abundantly with hematite in the Haycock iron mine. In other localities in Hull and Templeton townships, blue, green, and purple fluorspar occurs in apatite deposits.—In Pontiac county, fluorspar occurs in Huddersfield township.—Fluorspar occurs with beryl, garnet, muscovite, native bismuth, and bismuthinite, in a granite dike on the Kewagama River, Abitibi county, about 8 miles from Kewagama Lake,—Dark purple fluorspar is found in white calcite veins in slate near the citadel, Quebec City.—A small vein of purple fluorspar occurs in the gray limestone in Montreal.

ANDALUSITE

This is one of a group of silicates of aluminum including also **sillimanite,** and **cyanite,** of late years assuming importance in the manufacture of refractories, particularly spark plugs and refractory bricks. The minerals are found in metamorphic rocks such as gneiss, schist, and quartzite, usually near contacts with

intrusive igneous rocks. Their occurrence in masses sufficiently large and pure for mining is very rare. They are hard minerals, and a little heavier than quartz. Andalusite is white, reddish, grayish or green. Sillimanite is brownish, gray or pale green. Cyanite is usually blue but is sometimes white. The cleavage of the three minerals is perfect.

Andalusite occurs in small, flesh-red crystals in micaceous slate at Lake St. Francis, but the quantity is not important.

Cyanite is abundant in gray gneiss at Snake Creek, in Pontiac county, 10 miles north of Mattawa. It also occurs along the Grand Lake Route, and at Les Erable rapids, Temiskamingue county.

Sillimanite is a fairly common mineral in Grenville garnet-gneiss

These minerals have not been found in economic quantities in the province of Quebec. Their occurrence in such quantity and concentration as to form a commercial deposit is quite exceptional.

CHAPTER XII

NON-METALLICS (Cont'd.)

IRON PYRITES, SULPHUR, GRAPHITE, MICA, PHOSPHATE, TALC, ASBESTOS.

IRON PYRITES

Introduction. It is also called **pyrites** and **pyrite.** It is a compound of iron and sulphur. It is valuable for its sulphur, of which the pure mineral contains 53.3 per cent. It burns easily in a furnace called "**pyrites burners,**" where the sulphur is oxidised to sulphur dioxide, a gas used in the manufacture of sulphuric acid, and many other chemicals. This gas is also used to make **bisulphite of lime** in the sulphite process for paper-making from wood. The residue of oxide of iron, sometimes called **blue billy,** has been used as iron ore, but unless the sulphur is completely burned away, its presence lowers the quality of the iron and steel.

Pyrite is a yellow mineral, the shade varying from golden-yellow to yellowish gray. It is harder than steel, with which it easily strikes fire. Its specific gravity is 4.95 to 5.1. The fine powder is black. Well-formed crystals of pyrite often occur, cubes, octahedrons, and cubes with edges bevelled in a rather com-

plicated way (pyritohedrons) being the commonest forms. When the mineral is fine-grained, as it usually is, these crystal forms are not obvious.

As the prices paid for pyrite are small, from $4 to $6 a ton f.o.b. at a railway, the requirements for an ore body commercially workable are rather exacting. It must be fairly pure pyrite. If it assays 50% sulphur, this requirement is well met. Ore carrying 40% sulphur is marketable, if other conditions are satisfactory. Pyrite that is obviously mixed with a large proportion of rock is of no value as pyrite. The absence of arsenic and antimony is desirable, as these elements hurt the quality of sulphuric acid made from pyrite containing them. Selenium is also objectionable for the same reason. Lead and copper must not be present in more than small proportions, as they make the ore more easily fusible and so introduce difficulties in burning. Lead, lime, and some other substances hold back a certain proportion of the sulphur, and so decrease the value of the ore. Pyrites carrying more than 8 per cent of copper cannot be profitably used in making sulphuric acid, but it could be smelted for copper. Another condition is that the ore body must be large enough to warrant development and to maintain a steady supply for a number of years. The low price of the product makes it imperative that the deposit should be near transportation. The discovery of beds of sulphur in Louisiana and Texas put large supplies of nearly pure sulphur on the market at a price with which Canadian pyrites could not easily compete. But it is only a matter of time until the sulphur deposits are exhausted or more expensive to

mine. That this time is not far distant is shown by the tendency to higher prices for sulphur. It is said that certain manufacturers of sulphuric acid are already looking into Canadian pyrite deposits.

Pyrite weathers rather easily, forming one product that is obvious, iron rust or **limonite,** and another, **sulphuric** acid, that washes away. The limonite or **gossan** capping is a guide to pyrite deposits, but it should not be forgotten that a number of other iron minerals, such as pyrrhotite, also weather so as to form gossan. The capping is sometimes hematite, a reddish material. These signs of a pyrite deposit are easily seen when on a hillside where not covered by soil, but as pyrite weathers faster than the rocks in which it is found, the deposit may underlie a hollow. A very rusty soil (brown or red) that passes into soft limonite or hematite with depth should be trenched to solid rock.

PYRITE IN QUEBEC

EASTERN TOWNSHIPS

The most important production of pyrite in the province of Quebec has been from deposits in the townships of Ascot, and Weedon. The pyrite occurs as lenses in schists thought to be of Precambrian age. They are mostly altered igneous rocks, both acid and basic They form a belt, the **Ascot** belt, about 70 miles long and striking northeast-southwest. The most productive part has been that section of the belt, about 20 miles long, lying northeast and southwest of the city of Sherbroke. The first discoveries were made between 1860 and 1870, and the ore was first worked for gold, of which it carries very little. Then it

was discovered that a little copper pyrites was mixed with the pyrite. This led to the extraction of copper from the ore (See **Copper**, p. 58). Finally, the most important use was as a source of sulphur for the manufacture of sulphuric acid. The Eustis and Capelton mines, discovered in 1863, are still in operation, and development is being carried on at depths of 3000 to 4000 feet.

The **Eustis** mine is about 7 miles south of Sherbrooke. The largest lens extended from the surface to a depth of nearly 800 feet. Its horizontal dimensions were variable, up to 250 feet along the strike of the schist and up to 70 feet across the strike. The ore is free from arsenic and other deleterious impurities. It carries 40 to 45% sulphur and sometimes as high as 50%. The copper content of the ore taken out in the early part of the history of the mine was usually less than 2%, and the gold and silver values were very small. The ore now being mined carries from 2½ to 3% of copper. By selective flotation it is separated into concentrates high in copper, and pyrite carrying 50% of sulphur or over. It is said that the Eustis ore was the first pyrites used in America for making sulphuric acid.

Capelton Mines. This group of mines adjoining the Eustis property was operated from 1863 to 1908. The mines have lately been reopened. The orebodies are lenses of pyrite similar to those of the Eustis, but generally higher in copper, usually carrying over 5% and sometimes as high as 15% or over. The Capelton and Eustis properties are owned by the Nichols Chem-

ical Company. Large sulphuric acid works were built at Capelton, and also a copper smelter.

Victoria Prospect. This adjoins the Capelton on the east. It is on the same strike as the Eustis and Capelton ore zone.

Howard Mine. This mine is on lot 5, eleventh range, Ascot township. Operations ceased after the first lens was worked out, at a depth of about 200 feet. The ore was pyrite with a small percentage of copper.

King Mine. This is on lot 4, adjoining the Howard, the orebody of which extends into the King property. The ore carries as high as 12% copper. The mine has not been worked since 1910.

Moulton Hill Mine. This and the Howard were worked bythe Graselli Chemical Company. The Moulton Hill mine is on lots 23 and 24, third range, Ascot township. The orebody was a lens of pyrite in sericite schist The schist is cut by quartz veins and stringers and carries considerable scattered pyrite. The orebody was a mixture of pyrite with copper pyrites.

Weedon or McDonald Mine. This mine is on lot 22, first range, Weedon township, about 7 miles from Weedon station on the Quebec Central railway. The orebody was discovered in 1909, by carefully planned prospect pits and shafts. It consists of pyrite carrying about 5% of copper. The mine was operated from 1910 to 1920, and produced a good deal of ore.

Garthby Prospect. This prospect is about 5 miles northwest of Garthby station on the Quebec Central railway. The small amount of work done shows pyrite of good quality. A sample gave over 45% sulphur.

Other Prospects. Pyrite carrying copper values has been mined at a number of points in Ascot township, including the **Clark Mine** on lot 11 of the seventh range, the **Sherbrooke** on lot 12 of the seventh range, the **Hepburn,** on lot 7 of the ninth range, the **Suffield** on lot 3 of the eleventh range, and a number of others.

Most of the pyrite deposits in the Eastern Townships carry copper, but they are valuable rather for their sulphur than for their copper content, and some are indeed barren of copper. When the demand for pyrite as a source of sulphur fell off owing to the large supply of cheap sulphur from the Louisiana deposits, the Quebec pyrite mines were closed down. The larger expense of rasing the Louisiana sulphur and the approaching exhaustion of these deposits has led to a renewed interest in pyrite deposits. This in part explains the re-opening of the Eustis and Capelton mines. Doubtless there are still large resources in pyrite in the Eastern Townships The discovery of the Weedon Mine shows what can be done by well-directed prospecting.

CHIBOUGAMAU

Lake Chibougamau lies about 130 miles northwest of Lake St. John. The Chibougamau mineral area is around the north end of the lake and westward around lakes Doré, David and Simon. The country is underlain by Keewatin volcanics intruded by masses of anorthosite and granite. There are extensive zones of mineralization, with iron sulphides, and in places there are bodies of sulphides carrying enough copper pyrites to make them copper ores suitable for concen-

tration by the flotation process. If such ore bodies are found to persist in depth, a valuable by product of their concentration will be pyrite. (See **Copper** p. 61).

NORTHWESTERN QUEBEC

The copper-gold deposits developed of late years in the townships of Rouyn, Dufresnoy, Boischatel and other townships will doubtless be worked in two ways according to the percentage of copper. If this exceeds about 8 per cent. the ore will be smelted as a whole, but if the copper content is much lower, the ore will be separated by selective flotation into a concentrate containing the copper and a major part containing the pyrite and pyrrhotite. This part will be available as a source of sulphur. The Aldermac mine in Boischatel township is an example of this kind. The ore of one large body averages 1.5% of copper, and it contains a large proportion of pyrite and pyrrhotite. There are also bodies of pyrite like the Chance, barren of gold.

UNGAVA

On Eastmain River, half a mile above the mouth of Wabamisk River, is a large deposit of solid pyrite in chlorite schist. It is about 10 feet wide and can be seen for 100 feet along the bank of the river.

Reference: Pyrite in Canada, by A. W. G. Wilson, Mines Branch, Ottawa, publication No. 167.

SULPHUR

Sulphur has not been found in Quebec in economic quantities. Important deposits of sulphur occur in

volcanic regions, as in Sicily and Iceland, and as surface deposits such as are being worked in Louisiana and Texas. As Quebec has no volcanoes that have been active for a great many million years and as the country has been so severely glaciated that surface deposits have been pretty completely scattered, it is not likely that important deposits of native sulphur will be discovered in the province. Combined sulphur in the form of pyrite is plentiful (See **Pyrite** p. 207). Another source of sulphur, already being partly utilized, is the deposits of copper pyrites and pyrite in the Eastern Townships.

GRAPHITE

Introduction. Graphite is a crystalline variety of carbon. Diamond is another crystalline variety. Non-crystalline or amorphous carbon is known as coal, coke, charcoal, lamp-black, etc. Amorphous carbon such as coke can be made to crystallize when heated by electricity. It then becomes graphite. While graphite burns with the formation of the same product, carbon dioxide, as is yielded by the combustion of coal, coke. and charcoal, it burns very slowly, so that it can be used in the manufacture of graphite crucibles, arc light electrodes, etc. Its softness makes it useful in the manufacture of lead pencils. As it is a good conductor of electricity, it is used to give a conducting surface to objects on which metal is to be deposited by electric current. This property also explains in part its usefulness for electrodes. Its softness and its resistance to oxidation make it a suitable substance for foundry facings.

Varieties of Graphite. Three varieties are recognized commercially, (1) Crystalline, (2) Flake, and (3) Amorphous. **Crystalline graphite** is in masses of crystals not definitely in flakes. It is found in small veins or in bunches and pockets along the intrusive contacts of pegmatite dikes with crystalline limestone. schists, etc. It is the purest form of graphite and can usually be marketed after hand-picking. The veins are so small that they can be profitably mined only where labor is cheap, as in Ceylon. **Flake graphite** is also crystalline but in the form of separate flakes scattered through the enclosing rock, which is crystalline limestone, gneiss, or schist. The deposits are found in the neighborhood of intruding pegmatite dikes, etc., especially those of the gabbro or anorthosite type. Dikes of the granite type do not have graphite ore-bodies associated with them. The richest deposits occur at the crests of rock-folds or at other points where a relief of pressure has occurred during the folding process. This tends to give a saddle shape to the ore-bodies. **''Amorphous'' graphite** is in crystals so small that they can not be distinguished without the aid of a microscope. This gives the material a dull appearance. It is commonly found mixed with slate or shale, but sometimes in beds or vein-like masses consisting almost altogether of graphite. Some of these beds have been derived from coal by the action of intense heat. Crystalline and flake graphite are the highest priced. The ''amorphous'' variety is not suitable for the manufacture of graphite crucibles.

Mining and Milling of Graphite. While the veins of crystalline graphite are small, involving a good deal

of dead work in mining, it is always possible that an unusually wide vein may be discovered. At present Ceylon supplies almost all the world's demand for crystalline graphite, from veins so narrow that it would not pay to work them in Canada where wages are so much higher. Hand cobbing is about all that is required to prepare this vein-graphite for the market. At present it is almost exclusively used in the manufacture of graphite crucibles, but recent experiments have shown that flake graphite is equally suitable for this purpose. The difficult problem for Quebec graphite producers is the milling. The flake graphite is mixed with the rock, the percentage of graphite averaging from 7 to 12. Many mills have been built and many methods of concentration tried, but with only partial success. Oil flotation methods, so successful with metallic ores, have lately been tried with graphite and with a considerable degree of success. If such methods prove to be practicable, it is likely that the leaner ore bodies can be profitably worked. The nature of the rock in which the graphite occurs is a factor in the problem. A soft rock like crystalline limestone or soft schists is favorable. Some varieties of gneiss are so hard and compact that even when rich in graphite they may not be workable. The flakes are too much ground up in freeing them from the rock. The larger the flakes, the better the price.

Uses of Graphite. About 75% of the world's production was formerly used in the manufacture of crucibles and other refractory utensils used in metallurgical processes, but the introduction of electrical furnaces has reduced the market for crucible graph-

ite. The increased use of natural graphite for dry batteries has pretty well balanced this loss. The remainder is used as lubricants, pencils, foundry facing, stove polish, paints, in boilers to prevent scale, and for several other purposes. Artificial graphite made by heating anthracite coal or petroleum coke in electrical furnaces is a formidable competitor with the Papineau county.

GRAPHITE IN QUEBEC

The mining and concentration of graphite have proved to be difficult operations to carry on profitably. To produce a pure material, free from grit or from materials that lower the softening point of crucibles, requires ore of exacting quality and a concentration process of unusual difficulty, if a product of uniform and good quality is to be insured.

Quebec produced about 1845 the first graphite mined in Canada. Crystalline graphite or plumbago was taken out on lot 10, range five, Grenville township, Argenteuil county. This deposit was worked intermittently for a number of years, the latest operations being in 1899, when the property was operated as the Keystone Mine. Other deposits were worked many years ago in Lochaber and Buckingham townships, Papineau county.

The workable graphite deposits of Quebec, so far as known, are mainly in Buckingham township in an area extending from near the edge of the Paleozoic rocks in the south to range twelve in the north, a distance of about ten miles. There are a number of deposits in Argenteuil county east of Buckingham, and

small deposits are known in the district west of Buckingham township as far as the eastern part of Pontiac county. There is also a good deposit in Boyer township, much north of the Buckingham area. Doubtless others will be discovered, as the crystalline limestone formation is known to occur far east and north of the Buckingham area. Most of the graphite in this area is of the flake variety, disseminated in crystalline limestone and gneiss. Crystalline graphite is not uncommon in the district, but the veins are so narrow and irregular, that they can hardly be profitably worked in competition with the crystalline graphite of Ceylon where labor is so much cheaper. It is always possible that the exceptionally large and pure deposit may be discovered, as in Ontario at the Black Donald Mine, where the graphite, though rather of the "flake" variety than "crystalline," is in a vein-like body. The flake ores are in many cases high-grade compared with flake ore profitably concentrated in other countries, but the rock and secondary minerals accompanying the graphite are sometimes hard and expensive to crush The average graphite content of the ore treated in Quebec mills has been from 7 to 12 per cent.

The Buckingham graphite area is underlain by crystalline limestone, gneiss, and quartzite of the Grenville series, intruded by pegmatites ranging from granite to gabbro in composition. The graphite deposits are commonly associated with the basic intrusives such as gabbro and anorthosite.

The following short mention of some of the known graphite deposits in the province of Quebec is ar-

ranged alphabetically according to counties and districts.

ARGENTEUIL COUNTY

GRENVILLE TOWNSHIP

Graphite deposits of the crystalline type have been worked on lots 16, ranges two and three, west of Calumet station on the North Shore Montreal-Ottawa line of the Canadian Pacific railway. The veins are small, ranging from 3 to 18 inches in width.

The Miller Mine was first worked about 1845. The graphite is of the crystalline variety in narrow veins near an intrusive contact. The graphite is intergrown with such contact minerals as garnet, pyroxene, etc., which render it hard to mill, but it is said that a good deal of marketable ore has been obtained by hand-cobbing. The property was last worked in 1900. It is 3½ miles north of Grenville station on the North Shore Montreal-Ottawa line of the Canadian Pacific railway.

WENTWORTH TOWNSHIP

Twelve miles north of Lachute station on the North Shore Montreal-Ottawa line of the Canadian Pacific railway is a graphite property of the Canadian Graphite Company. The graphite is of the flake variety, the mineral being disseminated in a zone of calcareous gneiss about 30 feet wide. This zone has been traced for 600 feet. It is in contact with an intrusion of anorthosite. The ore is said to average 15 to 20 per cent of good quality flake graphite

LABELLE COUNTY

AMHERST TOWNSHIP

Twelve miles from St. Jovite station on the Montreal-Mont Laurier branch of the Canadian Pacific railway there is a zone of graphite-bearing rock 200 feet wide and about two miles long. This deposit is on lots 15 and 16 of range seven. It is at a contact of crystalline limestone with intrusive gabbro. There is flake graphite in the limestone and adjacent rocks, but the greater part of the ore approaches plumbago in character. It is, however, intimately mixed with hard minerals, necessitating milling to separate the graphite. The irregular form of the ore bodies makes a good deal of dead work necessary in mining. The milling ore is said to carry about 15 per cent of graphite.

BOYER TOWNSHIP

The graphite property of the Canadian Graphite Corporation comprises lots 27 to 30 of ranges six and seven. The mill is about two miles east of Guénette station on the Montreal-Mont Laurier branch of the Canadian Pacific railway. This mine is one of the very few now (1928) producing graphite in the province of Quebec.

PAPINEAU COUNTY

BUCKINGHAM TOWNSHIP

The graphite deposits in this township are numerous in ranges four to ten on both sides of the Lièvre River, but the largest number of mines and prospects occupy a comparatively small area around Donaldson Lake northwest of the village of Buckingham. There

are several mines and prospects east of Buckingham.

The deposits on lots 1 to 5, range four, are about three miles east of Buckingham. The graphite is of the flake variety and occurs in a series of bands in calcareous gneiss. The ore is in small bodies, but is found all over the property. As the rock carries iron sulphides in addition to graphite, a rusty covering is often a good indication of graphite. The bands of graphite ore are mostly narrow, a width of 9 feet being unusual. The problem of mining profitably is much like that of mica mining, where there may be a great many small bunches that may be profitably taken out, and only occasionally a large deposit that makes a real mine. Two shafts sunk to a depth of 70 feet on this property encountered little ore. The ore has therefore been taken out by surface pits. It is disseminated flake of good size and quality, and the ore is stated to average 14 per cent of graphite. The property has been operated by the New Quebec Graphite Company.

The Bell Mine is on lots 1, 2, and 3, range five, north of the New Quebec Graphite property and about four miles east of Buckingham village. The ore body is a band of disseminated flake graphite in crystalline limestone and gneiss. It has been traced for 2000 feet in length. The ore has been taken out by an adit in a hillside. It is said to average 8 per cent of graphite.

The Dominion Mine is on lots 20 and 21, range five, about three miles west of Buckingham village. The graphite is found at the contact of crystalline limestone with intrusive gabbro, and also disseminated in the limestone. On lot 23, range four, is a well-defined band of ore along a contact between

gneiss and pegmatite. This ore is remarkable for the size of the flakes, some measuring over 5 inches in diameter.

The **Weart** property includes lots 25 and 26, range six, and a number of adjoining lots, about 7 miles west of Buckingham village. One vein measuring 18 inches was followed to a depth of 70 feet where it split up into narrow stringers. The graphite is in gneiss near a contact with pegmatite.

The North American Mine is on lot 28, range six, 8 miles west of Buckingham. There are extensive workings in parallel bands of graphite ore forming a zone about 300 feet wide and 2000 feet long. Part of the ore has been taken out by an adit run several hundred feet into a hill. This mine has been operated lately by the Crucible Graphite Co., Ltd.

The Walker Mine is on lots 20 and 21, range eight, about 7 miles northwest of Buckingham village. Very pure graphite occurs at a contact of crystalline limestone with pegmatite. In other places, the graphite is disseminated in crystalline limestone near pegmatite contacts.

The Peerless or Diamond property includes lot 12, range nine, lot 14, range ten, and a number of other lots in ranges nine and ten. On lot 12 range nine, a body of flake graphite 6 feet wide has been worked to a depth of 70 feet by an open pit 100 feet long. The ore is said to have averaged 8 per cent graphite.

The Cummings property is on **lot 15 B, range nine.** There is a deposit of graphite consisting of a number of parallel bands in gneiss and crystalline limestone,

the whole forming a zone about 100 feet wide and 1000 feet long.

LOCHABER TOWNSHIP

The deposit of flake graphite first to be opened up in Canada was worked about 1864 on lot 23, range twelve. It is said that the ore raised carried 20 per cent of graphite. On lot 23, range eight, are a number of irregular veins in crystalline limestone at a pegmatite contact. There are a number of promising prospects on lots adjacent to those mentioned. Surface ore carrying 10 to 15 per cent of graphite is described as occurring in ore bodies 3 to 20 feet wide.

HULL COUNTY

LOW TOWNSHIP

The **McLean and Fitzsimmons** property is on lots 17 to 20, range three, about 3 miles from Low station on the Gatineau branch of the Canadian Pacific railway. The deposit consists of irregular bands of plumbago or crystalline graphite along the contacts between crystalline limestone and intrusive dikes of gabbro. There is also some flake graphite disseminated in large scales both in the gabbro and in the limestone. Graphite outcrops have been found over a considerable area.

OTHER LOCALITIES

Graphite occurs in a number of townships including Blake, Cameron, Hincks, Hull, Northfield, and Wakefield.

MANIWAKI INDIAN RESERVE

A belt of crystalline limestone carrying flake graphite crosses lot 10, Gatineau front. Where the limestone is in contact with granite, it carries graphite for a width of about 500 feet. In this contact zone there are rich bands that may be workable as graphite ore.

Reference: Graphite, by Hugh S. Spence, Mines Branch, Ottawa, publication No. 511.

MICA

Introduction. Two members of the Mica family are used in the industries, **white mica or muscovite,** and **amber mica** or **phlogopite.** Most of the mica produced is used in the electrical industries, where its usefulness depends on its insulating power, its incombustibility, and its easy splitting into thin sheets. A third member of the family, **black mica** or **biotite,** sometimes occurs in large "books" or crystals that split nicely, but the high iron content of the mineral makes it a poor insulator for electricity. It has of late been used for making ground mica. The micas are all silicates, but differ somewhat in the rest of their composition. White mica is silicate of aluminum, and potassium. Amber mica is silicate of aluminum, potassium and magnesium. Black mica is silicate of aluminum, magnesium, and iron, with more or less potassium. White mica and black mica have some hydrogen in their composition, and there are other variations. In addition to the three micas mentioned, a number of other minerals

belong to the family, but no others are used for the purposes for which white and amber mica are useful.

White and amber mica are common minerals as constituents of such igneous rocks as syenite, granite, etc., but they usually occur in crystals too small to be of any use. To be useful, mica crystals must not only be large, but they must be free from crinkles and cracks, and must not be pierced or stained with other minerals, particularly with oxides of iron that would impair the insulating power of the mica. The quality of the mica is sometimes lowered by thin layers of other minerals such as calcite between the layers of mica. This causes the mica to split unevenly and with difficulty.

White mica of commercial quality is found in pegmatite granite, where all the minerals are in large crystals and more or less separated into bunches, so that the mica, feldspar, and quartz can be taken out separately. Pegmatite dikes are very numerous in Quebec, but it is only the exceptional dike that contains commercial white mica. These exceptional cases may be looked for around masses of granite, syenite, and gneiss.

Amber mica is found in "pyroxenite dikes," particularly in regions where crystalline limestone is in contact with gneiss and schists. The limestone and the gneiss occur in bands, and the "pyroxenite dikes" usually follow the strike of these rocks, about northeast-southwest, although in some cases cutting across the strike. These dike-like structures are thought to be metamorphic zones caused by the influence of granite intruding the limestone. The Laurentian granite was

itself changed into gneiss. The dull greenish-gray color of the pyroxene rock is a guide in prospecting for the mica. In the same rock occurs apatite (See **Phosphate**. p. 241), but the mica miners say that the mica is not so good in the neighborhood of the bunches of phosphate. The pockets or veins of mica are usually associated with calcite. The distribution of the mica in the dikes is very irregular and uncertain. This makes mining difficult. When a bunch of mica crystals is taken out there is no clear indication of the location of another bunch. Sometimes a small vein of calcite has been followed up with good results, but most of the small operators prefer to prospect on the surface. It is cheaper and more rapid than underground prospecting. Some method of locating hidden bodies of mica is desirable. Diamond drilling, so useful in other mineral deposits, yields only uncertain results in prospecting for mica. It is possible that more careful study of the mica deposits may enable geologists to interpret the results of diamond drilling with more certainty.

Uses of Mica. The greater part of the mica produced is used in the electrical industries to separate the copper sheets in armatures and for other insulating purposes. Amber mica is considered to be better for commutators because it is not so brittle as most white mica, and wears evenly with the copper. But the Indian white mica is often preferred because of its uniform quality and its superior resistance to heat. A certain amount of the larger sizes is used instead of glass in stove fronts and lanterns. White mica is preferred for these uses, on account of the absence

of color and the superior resistance to heat. The waste from the trimming shops is ground to a powder to use on wall paper, to which it gives a silvery, glistening appearance; to mix with rubber, paint, oil and axle grease; for heat-insulating materials; as a coating for roofing paper to prevent the rolls from sticking; mixed with hard rubber for telephone receivers, etc; mixed with shellac, etc., to cover high tension electrical wires. The smaller sizes of mica, smaller than 1 inch x 2 inches, are used in making **micanite** or mica board. The mica is split very thin, from .001 to .005 of an inch, and then built up into sheets of the desired size by sticking layers of the pieces together by means of shellac. In this way sheets from one tenth to half an inch thick are made. They are then put under pressure, and finally ground to an even thickness. The sheets can be made of any desired size, and can be cut and shaped.

Prices of Mica. Scrap mica for grinding sells at $5 to $12 a ton. The prices of trimmed mica depend on the size, from 10 cents a pound for 1 x 3 inches, to $1.50 to $2.00 a pound for 5 x 8 inches. Larger sizes are sometimes required for special purposes and bring correspondingly higher prices.

MICA IN QUEBEC

MUSCOVITE OR WHITE MICA

ARGENTEUIL COUNTY

Grenville Township. White mica crystals of large size were mined on lot 9, sixth range, as long ago as 1853, but there has been no production of late years.

There are other occurrences of muscovite in the same township. Grenville township is on the north side of the Ottawa River. Grenville is a station on the Canadian National railway.

BERTHIER COUNTY

Maisonneuve Township. The Maisonneuve Mica Mine is on lots 1 and 2 of the second range, near Mica Lake. The mica is in a pegmatite dike 36 to 52 feet wide cutting across the strike of the gneiss in which it lies. The dike is at least 300 feet long, and muscovite crystals of large size are plentiful in it. There are a number of rare minerals in the dike, including beryl and samarskite. This deposit is about 30 miles north of Joliette.

CHARLEVOIX COUNTY

De Sales Township. Charlevoix county is on the north side of the St. Lawrence river, below Quebec city. Baie St. Paul is the nearest point on the St. Lawrence. The mica deposit is near Lake Pieds des Monts. The mica is in a pegmatite dike 300 feet long and 20 feet wide. Sheets of mica 10 to 14 inches have been produced. The distance from railways made it impossible to work the property profitably. The radioactive mineral cleveite occurs in this dike.

PAPINEAU COUNTY

Villeneuve Mica Mine. This mine is 20 miles north of Buckingham and 3 miles east of the Lièvre River. The property was worked from 1884 to 1888 and then at intervals till 1909, since which it has been idle. It has produced a large quantity of mica of excellent

quality from a pegmatite dike intrusive in gneiss. This dike is 150 feet wide. The mica occurs mostly along the contact. The mica is of a greenish tint and was formerly much in demand for stoves. Some of the crystals are very large. One weighed 281 pounds and yielded $500 worth of merchantable mica. A good deal of the mica is unsuitable for electrical purposes because of inclusions of garnet and other minerals that lower the insulating power. The radioactive minerals pitchblende and gummite occur in small quantities. Beryl, monazite, zircon, and purple fluorspar are occasionally found. One large mass of monazite is reported. The varieties of feldspar called amazonstone and peristerite are found in this dike. Feldspar has been mined as a by-product. It is of unusually good quality.

HULL COUNTY

Wakefield Township. The Leduc mine has been worked for feldspar and for mica, but an analysis of the latter showed it to be lepidolite or lithium mica. It is unsuitable for electrical purposes, but is valuable as a source of lithium. The radioactive minerals uraninite and gummite are found in small quantities.

Other Prospects. Pegmatite dikes are numerous in the townships of West Portland, Hull, and Buckingham, but the mica that has been found is mostly of no value because of stains and inclusions.

LAKE ST. JOHN REGION

Many discoveries of muscovite have been made in the Lake St. John region, but remoteness from trans-

portation makes their exploitation impracticable. The chief discoveries have been made in Pontbriand township around the headwaters of the Peribonka River. The mica is said to be of good size and very clear.

Another discovery is near Notre Dame des Anges on the Batiscan River.

PORTNEUF COUNTY

Muscovite occurs in a dike on an island in the Upper St. Maurice River, Portneuf county. It is associated with black tourmaline.

SAGUENAY DISTRICT

Numerous pegmatite dikes have been observed on the east side of the Saguenay River, and merchantable muscovite has been found in some of them, especially in the townships of Bergeronnes, Tadoussac, and Escoumains. The mica is generally of a dark rose color when viewed in thick sheets.

The **McGie Mine** is in block G, Bergeronnes, 12 miles from Lac des Escoumains. The dike is a quarter of a mile long and from 15 to 75 feet wide. Mica crystals, some of large size, are plentiful. Trimmed mica of sizes 3 x 4 inches to 7 x 10 inches has been produced. Very fine crystals of tourmaline, garnet, and beryl are found in this dike.

The **Moreau Mine** adjoins the McGie property. The pegmatite dike shows some very fine, transparent mica crystals.

The **Hall Mine** is on Beaver Lake at the head of Little Bergeronnes River, about 11 miles from the St. Lawrence River. The dike is from 100 to 300 feet

wide. The mica crystals are colorless, and yield mica of exceptionally fine quality.

In addition to these better known mica properties, there are a large number of others on which mica of good quality has been found, but their remoteness from transportation prevents their development at present. Some of these are north of the McGie Mine, around the head waters of the Beaulieu and Bas de Soie rivers.

Between Tadoussac and Bergeronnes, on the **Little Bergeronnes River,** a pegmatite dike has been found in which large mica crystals occur.

Near **Anse à Caron,** Jonquière, it is reported that crystals of dark mica occur two feet in diameter.

OTHER OCCURRENCES

There are numerous pegmatite dikes along the north shore of the Gulf of St. Lawrence, north of Anticosti Island, and some of them carry merchantable muscovite in addition to feldspar. The best dikes are to be seen on the east coast of Quetachu Bay, Manikuagan.

Merchantable mica is reported at points in Ungava, including one on Eastmain River, but these occurrences are too remote to be of importance at present.

PHLOGOPITE OR AMBER MICA

The area so far most productive of amber mica lies north of the city of Ottawa, between the Gatineau and the Lièvre rivers, and west of the Gatineau River and east of the Lièvre River. The typical green pyroxene rock is to be seen in most of the outcrops in the

townships of Templeton, Wakefield, Hull, Portland, Villeneuve, etc., and this rock is known to extend westward into Pontiac county as far as the townships of Bryson and Waltham. Eastward in Argenteuil county, mica outcrops have been found in Wentworth and Harrington townships, and as far east as Montmorency and Wolfe counties near the city of Quebec. The northern boundaries of the mica-bearing rocks are not known, but they extend beyond the limits of present profitable exploitation of the mica.

Many properties were worked for phosphate during the time when prices for that mineral were good. The mica occurring with the phosphate was thrown on the dump. Later, when the cheap Florida phosphate made it unprofitable to mine phosphate in Quebec and the growth of the electrical industries created a demand for mica, the phosphate dumps were worked over and large quantities of mica were sorted out.

Mica has been discovered in so many places and small quantities have been taken from such a large number of properties that it is not possible to mention them all. A few of the more important are described shortly.

THE LIEVRE RIVER DISTRICT

PAPINEAU COUNTY

Mica has been mined in the townships of Buckingham, East Portland, Derry, Villeneuve, Wells, and Bigelow. These townships lie along the Lièvre River which flows southward and empties into the Ottawa River at Buckingham. The district first came into

prominence as a producer of phosphate, but in later years has yielded a large quantity of amber **mica,** which has been mined in twenty or more places in the district, mostly in the townships of Villeneuve, Derry, and East Portland.

East Portland Township. The **Poupore Mine** is on lot 1 of the first range, close to the main road from Buckingham to Glen Almond. It has yielded several tons of mica of fair size and quality.—The **Little Rapids Mine** on lot 6 of the same range was formerly an important producer of phosphate, but later produced some dark amber mica.—The **O'Brien and Fowler property** on lots 1 and 2 of the third range shows mica at many places, generally in small pockets with pink calcite. Large quantities of phosphate have been found and considerable mica in crystals of medium size and of excellent quality. From one drift was taken a crystal measuring 24 by 18 inches on the face. Some mica has been produced from workings on lots 16 and 17 of the eighth range and lot 9 of the ninth range, also owned by O'Brien and Fowler.

Derry Township. The **Cameron Mine** is on lot 5 of the first range. A considerable quantity of mica has been produced.—The **Daisy Mine** on lot 9 of the first range, and a property on lot 7 of the second range at the foot of the hill on which are the Daisy Mine workings, have been considerably developed.

Villeneuve Township. The **Gautier Mine** is on lot 2 of the second range, close to the Lièvre River and about three miles south of Val des Bois. There are a number of pits sunk on a line of pockets in pyroxenite rock near its contact with gneiss. The mica is of me-

dium size and fair quality.—The **Moose Lake Mine** is on lot 1 of the fourth range, and is owned by O'Brien and Fowler. The extensive workings are in pyroxenite rock lying between gneiss and crystalline limestone in a zone over 300 yards wide. Mica is found across the whole width. It is of good quality, but not of large sizes, mostly 3 by 5 inches and under. There has been a large production from this property.

Wells Township. The **Oriole Mine,** on lot 14 of the third range, has produced a large quantity of mica of good quality. The mica is found in pockets in pyroxenite rock in contact with gneiss.

Bigelow Township. The **Parker Mine,** on lot 52 of the fifth range, is three miles from Notre Dame du Laus. The mica occurs in pyroxenite that is in contact with crystalline limestone. The crystals are of medium size and dark amber in color. Surface indications are good.

CENTRAL MICA REGION

This includes the townships of Templeton, Wakefield, East Hull, and West Portland, in the counties of Hull and Papineau, (formerly Ottawa). It lies between the Lièvre and Gatineau rivers. Mica has been found in 130 or more places in this district.

Templeton Township. The **McElroy Mine,** on lot 22 of the sixth range, is five miles southwest of Perkins Mills. Some very large crystals have been taken out. The mica is reddish amber, rather brittle, and sometimes ribbony.—The **Rainville** or **Dugas Mine** is on lot 15 of the eighth range. It is about a mile and a

half from Perkins Mills. Originally operated as a phosphate mine it later became an important producer of mica, about 17 tons of which were obtained by turning over the old phosphate dumps and opening up some shallow pits. Some very large crystals were taken out yielding sheets 40 by 45 inches. Up to 1912 it was estimated that $200,000 worth of mica and 2000 tons of phosphate had been taken from this property.—The **Phosphate King** is on the west half of lot 15 of the eighth range, and its deposit is continuous with that of the Rainville. A large amount of mica has been produced from open pits and from an adit driven into the hillside.—The **Wallingford Mine** is on the west half of lot 16 of the eighth range adjoining the Phosphate King. The mine has produced a large quantity of mica. One very large crystal is said to have yielded $33,000 worth of mica. The mica is light amber of best quality. It took first prize at exhibitions in Paris, St. Louis and Liège. The mica pockets occur along the contact between pyroxene and gneiss for at least 370 feet. For mica mines an unusual depth has been reached in the main workings, and the mica pockets recur unfailingly both horizontally and vertically.—The **Jubilee or Smith Mine** is on the north half of lot 10 of the tenth range. It was, like many of the mica properties, first worked for phosphate. The mica is light silver amber of first quality, and the proportion of large sheets is large. The deposit is on a zone of pyroxenite in garnetiferous gneiss. There are many mica and phosphate mines along this zone which passes through ranges ten and eleven of Templeton township. Among these may be mentioned on

range ten the **Murphy** on lot 10 south half, the **Victoria** on lots 15 west half and 16 north half, and on range eleven the **Blackburn** on lots 9 and 10, and the **Cornu** on lot 14.—The **Blackburn Mine** on lots 9 and 10 of range eleven has been the largest mica and phosphate mine in the township of Templeton. It is 4 miles from Perkins Mills. The mine was opened for phosphate in 1888. Up to 1912 it had been operated continuously with the exception of one period of three years. The workings have been unusually systematic for a mica mine, and included both open cuts and underground drifts and shafts. The depth reached was 280 feet. The mica is first class light amber, and about 50 per cent of the mica mined is commercially valuable. The deposit is in pyroxenite lying in gneiss. Pegmatite dikes often follow the mica leads. Throughout the zone of pyroxenite are pockets and chimneys filled with mica and phosphate. Both minerals are plentiful in the lowest workings.—The **Battle Lake Mine** is on lots 4 and 5 of range twelve. The operations on this property have been rather extensive, and a good deal of both phosphate and mica has been produced. The mica is first class light silver amber with excellent splitting qualities. The crystals are often of a large size. One crystal weighing 200 pounds cut to sheets measuring 14 by 19 inches. Another gave sheets 19½ by 27 inches. The property is on the north shore of Battle Lake and about 2½ miles from the Lièvre River.

Wakefield Township. At some 18 places in this township mica has been discovered, and it has been produced in the majority of them. A considerable

number of the best properties lie within 4 miles of Wilson Corners.—The **Kodak Mine** is on lot 6 of range two. It produces an excellent silver amber mica. The deposit is at a contact between proxenite and gneiss. The mica crystals are in pink calcite or form masses between the calcite and the pyroxene. The property has produced a large quantity of mica.—The **Lake Girard Mine** is on the south shore of Lake Girard 3½ miles northeast of Wilson Corners. It has been one of the most important mica producers of the district. For example, in 1893 the average daily output of mica crystals was 4½ tons over a period of three months. A depth of 210 feet was reached in the workings, but apparently the lead of mica failed to continue.—The **McGlashan Mine** is 3 miles north of Wakefield and near the west arm of Wakefield Lake. The mica is dark amber. It is often well crystallized and crystals of large size have been taken out in considerable quantity.

East Hull Township. The **Nellie and Blanche Mine** is on lot 10, range eleven, about 9 miles north of Ottawa. The mica is a dark amber and gave cuts 10 by 14 inches. At one time this mine was producing 40 tons of mica a month.—The **Vavasour Mine,** also called the **Nellis,** or **Gemmill,** is on lot 10, range twelve, about a mile north of the Nellie and Blanche. It was first opened for phosphate about 1892. The deposit is at a contact between pyroxenite and gneiss. The principal mica lead is 1200 feet long, but workings extend over a length of 2100 feet. The mica is a first class silver amber, and the crystals are often of large size, yielding a large proportion of cuts of 5 by 8 inches.—**Win-**

ning, Church & Co., of Ottawa, have worked a mica deposit on lots 12a and 13a of range thirteen, about half a mile east of the Gatineau River. The mica is an excellent light silver amber yielding a large proportion of cuts of 5 by 8 inches. The deposit occurs at a contact of pyroxenite with an intrusive granite rock. Fibrous actinolite occurs in the pyroxenite and a little molybdenite in the granitic rock. Some very large mica crystals have been taken out. The property has been looked upon as one of promise.—On **lot 12b** is a property that has been extensively worked It is one of a group along a ridge of gneiss cut by pyroxenite and intruded by granite dikes. This ridge is about 2 miles southwest of Wilson Corners. While the mica is not very plentiful, it is of excellent quality, and is seen in all of the numerous pits.—The **Horse-Shoe Mine** is on lots 15 north half, 16 north half, and 17, of range sixteen. Kent Bros. of Kingston took out $8000 worth of mica in a few months of 1909. The mica is dark amber and a little brittle, but the crystals are often of large size.

Portland West Township. There are about 10 or 12 mica mines in this township, which lies west of the Lièvre River and about 30 miles north of Ottawa. Some very large crystals are reported to have been taken out of a pit on lot 24 south half, range three.—**Range Four, Lot 27.** Originally opened as a phosphate mine, this property has produced a large quantity of mica. The mica and phosphate are associated with pink calcite in a pyroxenite zone in gneiss. Dikes of granite intrude the gneiss and pyroxenite.

GATINEAU RIVER AND WESTERN DISTRICT

HULL (formerly Ottawa) COUNTY

West Hull Township. Some of the best deposits in this township are along a ridge about two miles from Kingsmere. The ridge is underlain by gneiss and zones of pyroxenite, both being intruded by granite dikes, largely of the pegmatite variety. Along this ridge are the Wallingford, the Cliff, the Fortin and Gravelle, the Laurentide Mica Company, and a number of other properties.—The **Fortin** and **Gravelle Mine** is on lot 18 south half, range seven. This property has produced a large quantity of silver amber mica of first quality and with a high proportion of the larger sizes.—The **Laurentide Mica Company Mine** is on lot 19 adjoining the Fortin and Gravelle. There has been a great deal of surface prospecting and development on this property.—Mica has been mined in greater or less quantities on some 30 properties in this township.

Hincks Township. A few properties have been worked for mica in this township. The **Hastey** mine on lot 22, range two, produced a good deal of mica, some of it of large size, sheets having been cut measuring as much as 4 feet across. The deposit occurs at a contact between pyroxenite and crystalline limestone.

Wright Township. This township is mostly east of the Gatineau River and in the northern part of the district. Mica has been produced from four or five properties. The **Father Guay Mine** is on lot 15, range D, 6 miles northeast of Gracefield station on the Maniwaki branch of the Canadian Pacific railway. The

mine workings are extensive, and large quantities of mica have been taken out. The mica is amber of good quality and medium size. The deposit occurs at the contact of pyroxenite and crystalline limestone.

Cameron Township. The **Cleland** property is on lot 10, range two, three miles southeast of Bouchette. The mica deposits are near the contact of a pyroxenite zone with crystalline limestone. The mica at the surface is stained and of poor quality owing to the influence of a large proportion of pyrite in the rock, but below the weathered material, the fresh rock carries better mica. The mica is light amber and the crystals are of medium size. There are several mica leads.—The **Lacroix** property on lot 13, range two, has a mica deposit at the contact between crystalline limestone and pyroxenite. The mica is amber of fair quality and good size.

PONTIAC COUNTY

Alleyn Township. This township is west of the Maniwaki branch of the Canadian Pacific railway, and can be reached by road from Kazabazua station. There is a group of mica properties near the east boundary of the township, and not far from the Kazabazua River.—The **Anderson** property is on lot 3, range two, half a mile from the village of Danford Corner. The mica is dark amber of good quality, and the indications for quantity are considered good.—The **Moore and Marks** property is on lot 4 adjoining the Anderson. The mica is dark amber of good quality, and remarkable for the size of the crystals. One crystal measured 34 by 48 inches across the cleavage

and weighed 3000 pounds. The mica is in a pyroxenite zone at least 300 feet wide lying in gneiss. The workings are extensive.—The **Ellard Mine** is on lot 10, range two, about a mile from Danford Corner. It has produced a good deal of mica, and the indications are that there is still a large quantity in reserve.

Other Townships. More or less mica has been produced in the townships of Masham, Lytton, Denholm, Ripon, Low, Aylwin, Blake, Northfield, and Egan, all in Hull County, and in the townships of Canwood, Huddersfield, Litchfield, Waltham, Thorne, and North Onslow, of Pontiac County.

PRODUCTION

The production of mica in Quebec in 1928 was 2,553,350 pounds valued at $56,180. In 1927 the production was nearly double this amount. It has been suggested that the mica industry could be much improved by more careful grading and preparation for the market.

Reference: **Mica** by Hugo S. de Schmid, Mines Branch, Ottawa, Publication No. 118.

PHOSPHATE

Introduction. This name is used in commerce to designate all kinds of minerals composed essentially of phosphate of lime, including the mineral **apatite,** formerly extensively mined in Quebec, but now superseded by a sedimentary deposit that can be very cheaply mined in Florida and other southern states. The Quebec apatite deposits are comparatively small

and involve the kind of mining usually applied to veins. The apatite occurs in bunches, and the pyroxene, mica, etc., accompanying it must be mined as waste, although the mica is sometimes of commercial quality. Florida phosphate can be delivered in Quebec for less than the cost of mining apatite. This fact alone is responsible for the almost complete cessation of phosphate production in Quebec. Apatite differs from the Florida phosphate in being a definite crystallized mineral that can be obtained pure and unmixed with the clay, sand, etc., that dilute Florida phosphate. While these inert materials do not interfere with the principal use of phosphate, namely the manufacure of agricultural fertilisers, they reduce the percentage of phosphoric acid, the fertilising part of the material These impurities may also make the sedimentary phosphate unsuitable for the manufacture of new substances containing phosphorus. Such considerations as these make it advisable to keep in view the fact that there are still large quantities of apatite available in Quebec.

Uses of Apatite. The principal use is for the manufacture of acid phosphate or **superphosphate** to supply the phosphorus needs of crops, and for the manufacture of phosphorus. For use as a fertiliser, the value of the phosphate depends on the percentage of phosphate of lime, which is much higher in Canadian apatite than in Florida and Tennessee phosphate, which analyses 77 to 72% of phosphate of lime, while pure apatite contains about 90% and the mineral can be mined and cobbed to an 85% product.

The apatite occurs in vein-like leads or in irregular pockets, stringers, and lenses in pyroxenite which is associated with crystalline limestone and gneiss. When the mineral is not in vein form, mining is difficult. When a bunch has been taken out, a stringer may lead to another bunch, but following it requires dead work, and the other bunch is not sure to be there. With the phosphate are found calcite, usually of a pink color, mica, pyroxene, and many other minerals in smaller amounts. The presence of pyrite and other iron minerals is objectionable, and too high a percentage makes the phosphate unsaleable. The mica, the amber variety, is often in large crystals of commercial quality, and many of the mica mines were originally opened as phosphate mines. Phosphate and mica are in some cases being taken out of the same workings. The apatite varies in color, being usually greenish, but often brown, and sometimes red, gray or white. The mineral is sometimes well crystallized, and the crystals are often large, showing the characteristic six-sided prisms. Crystals several feet long and a foot or so in diameter are not uncommon. Some of the deposits are "sugar" phosphate, the mineral occurring as a mass of small rounded grains. This is apt to be the case in the larger deposits. Quebec phosphate is always the **fluor-apatite** variety, containing by analysis 82 to 87% of phosphate of lime and about 7.5% of calcium fluoride. There is usually a little calcite mixed with the apatite, and sometimes there are large masses of calcite with crystals of apatite scattered through it. As apatite is considerably harder than calcite, it is easy to distinguish them. These mixed deposits are

expensive to mine and cob, but they may be a source of phosphate in the future. The only production of phosphate in Quebec at present is from mica mines, and as the mica in deposits where phosphate is a principal constituent is apt to be of poor quality, such mines have been abandoned. Very little phosphate has been produced in Quebec since 1893. The small production of late years has been marketed at Buckingham, Quebec, for the manufacture of phosphorus. Phosphate mining in Quebec has not been carried to great depths, the deepest mines being only about 200 feet.

PHOSPHATE IN QUEBEC

The Province of Quebec has produced by far the greater part of the phosphate mined in Canada. The total production in Quebec since 1878 has been more than 300,000 tons. At present phosphate is produced in Canada only as a by product in mica mining, and the small quantity annually produced in this way is to be credited almost entirely to Quebec mica mines.

The Quebec phosphate deposits occur mostly in the townships of Templeton, Portland East, Portland West, Buckingham, and Wakefield, making a district lying largely west of the Lièvre River. The deposts carry mica as well as phosphate, but when the phosphate is largely developed, mica is apt to be scarce, and vice versa. An exception to this is seen in some of the Templeton mines that produced large quantities of both minerals. The amount of phosphate in proportion to the mica is believed to be smaller in the more northerly deposits. There is a concentration of rich de-

posits in the northwest corner of Buckingham township, and in Portland West township west of Lièvre River.

There are doubtless in the Lièvre River district large reserves of phosphate that may be profitably mined, should the exhaustion of more easily won surface deposits in Florida and elsewhere lead to higher prices. The known phosphate deposits are so numerous in the area under consideration, that only a small proportion of them can be mentioned here.

BOWMAN TOWNSHIP

High Falls Mine. The workings of this mine are on lots A, 1, 2, 3, and 4, range four, near High Falls on Lièvre River. The total production of the mine is estimated at about 1000 tons. There are extensive showings of phosphate in an adit that has been run 75 feet into a hillside. The mine was worked for less than two years, and was closed when the depression of prices came in 1892.

Brazeau Mine. This is about 5 miles north of High Falls, on lots 27 and 28, range five. It is the most northerly phosphate deposit known in this area. The mine is on a belt of phosphate formation that extends northwest from the Ross Mountain Mine in West Portland township to the Brazeau, a distance of about 10 miles. The Brazeau mine was worked in a small way for 20 years and produced about 1500 tons of phosphate, the greater part of which was taken from a pit worked to a depth of 40 feet. The deposit is said to be over 20 feet wide at the bottom

of this pit. The very small amount of waste rock on the dump indicates a large body of the mineral.

BUCKINGHAM TOWNSHIP

The known deposits of phosphate are confined to the northwest corner of the township on both sides of Lièvre River, in ranges ten, eleven, and twelve. South of this no important deposits of phosphate have been found, although a little occasionally occurs in calcite in the graphite deposits. The important phosphate mines are the Aetna, Squaw Hill, and Emerald, all in range twelve.

Aetna Mine. This mine is on the north half of lot 17, range twelve, about a mile northeast of the village of Glen Almond and about 8½ miles north of Buckingham village. The workings are at the eastern end of the belt of phosphate formation on which are located farther west the Squaw Hill and the Emerald mines. The collapse of the phosphate mining industry in 1892 interrupted developments at the Aetna before they were far enough advanced to show the dimensions of the phosphate body.

Squaw Hill Mine. This mine is on the south half of lot 18, range twelve, about half a mile from the village of Glen Almond. It has produced large quantities of phosphate from several pits, the main one being 140 feet deep.

Emerald Mine. The Emerald mine is about a mile west of the Aetna, and near the Lièvre River main road. It was one of the largest and most important phosphate producers in the province. The workings

are extensive and faithfully follow the rather irregular windings of the pockets of phosphate connected by narrow veins In one of the pits a vein of phosphate over 90 feet wide is said to have been opened up. The vein matter contains little calcite and mica. Pyrite is rather plentiful. It is estimated that this mine produced 35,000 tons of phosphate.

PORTLAND EAST TOWNSHIP

Phosphate has been found in some twenty-five places in this township east of the Lièvre River, most of which have not been developed past the prospect stage. The most important deposits from a roup in the southern part of the township, three or four miles northwest of the Aetna, Squaw Hill, Emerald group in Buckingham township. The Portland East group includes the Fowler and Bacon, Little Rapids, London, and Watts mines. The Little Rapids mine has been worked for both phosphate and mica.

Little Rapids Mine. This property includes lots 6 and 7, range one, and lot 6, range two. The principal workings are near the Lièvre River down which the phosphate was taken in scows to Buckingham, a distance of 12 miles. The phosphate and mica occur in the common pyroxenite rock which is intruded by small stringers of rock composed mostly of feldspar. Phosphate is seen at many places all over this property. From this and adjacent properties doubtless a good deal of phosphate could be taken, if a rise in price warranted the resumption of phosphate mining.

North Star or Haycock Mine. This mine is on lot 18, range seven, 4 miles northeast of the village of Notre

Dame de Salette on the Lièvre River. An inclined shaft 620 feet deep is probably the deepest in the phosphate country. Another shaft on this property is 250 feet deep. These and other openings are on the same phosphate lead, which is regular and persistent enough to be called a vein. This mine attained a yearly production of 8000 tons of phosphate. The amount of phosphate in sight when the mine closed down in 1891 is said to be considerable. One vein is 20 feet wide, and the veins showed no signs of narrowing with depth. As these veins carry mica as well as phosphate, their persistence at such depths not only indicates the possibility of carrying the mining of other phosphate deposits to greater depths than usual in phosphate workings, but also has a bearing on the possibility of comparatively deep mining for mica. The phosphate and mica are found in the common type of pyroxenite in contact with rusty gneiss, both rocks being cut by pegmatite dikes and stringers.

PORTLAND WEST TOWNSHIP

Phosphate has been found in about 20 places in this township, most of which are in a belt through ranges six, seven, eight, nine, and ten, parallel to the Lièvre River, and about two miles west of the river.

Fleming and Allan Mine. This mine is on lots 27 and 28, range four, about three quarters of a mile west of Lièvre River. It has been worked for both phosphate and mica, which occur in parallel veins associated with large quantities of pink calcite. The veins are in a band of pyroxenite in gneiss. These rocks are cut by pegmatite dikes.

Ross Mountain Mine. This property includes lots 5 and 6, range six, and lots 1 and 2, range seven. The deposits are the most southerly in the phosphate belt that runs parallel to Lièvre River along its western side. This belt is about 4½ miles long in Portland township and extends northward into Bowman township more than a mile. The principal workings, are on lot 5, range six, about half a mile from the shipping point on the Lièvre River. A good deal of phosphate seems to have been developed by pits and adits, but the depression in prices caused the closing of the mine before there had been much production.

Crown Hill or Little Union Mine. This mine is on lots 3 and 4, range 7, just north of the Ross Mountain property. The greatest depth reached was 120 feet. The total production up to 1891 is estimated at 35,000 tons. A few hundred tons has been taken out since that time. The apatite veins or leads lie in pyroxenite, and somewhat irregularly follow the strike of the ridge running parallel with the Lièvre River. Pyrite and pyrrhotite are present to a considerable extent. Amber mica of good quality occurs in small quantity.

High Rock Mine. This is considered to be the most extensively developed of all Canadian phosphate mines. The property includes lots 5, 6, 7, and 8, range seven, and lots 1 and 2, range eight. The mine was operated continuously from 1879 to 1894, and the total amount of phosphate produced during that time was about 85,000 tons. The workings consist of very large pits, the deepest of which was 200 feet deep. These pits were, in some cases, connected by drifts

following the veins. A vein of apatite up to 30 feet wide has been followed into the hillside by a drift for 350 feet.

Star Hill or Old Union Mine. This property is about one mile northwest of the High Rock Mine, and comprises lots 3, 4, 7, 8, and 9, range eight, and lots 5, 6, 7, 8, and 9, range nine. The apatite occurs in bunches scattered through pyroxenite in zones following the strike of the ridge. Both calcite and pyrite are absent. There were considerable quantities of amber mica of good quality. The phosphate was mined by pits some of which reached depths of 150 and 200 feet. The mine is connected with the Lièvre River by a 3½ mile road.

Central Lake Mine. This property is near the northern boundary of Portland township, and includes lots 7 and 8, range ten. The main workings are at the south end of Central Lake, and about a mile west of the Lièvre River. Mica is plentiful in some of the phosphate leads, and small quantities have been taken out since the cessation of phosphate mining in 1892.

HULL TOWNSHIP

Hull township is bounded on the south by the Ottawa River, and its western boundary is a little west of the Gatineau River. The phosphate deposits are in the northern part of the township. Phosphate has been mined in 25 or 30 places.

Vavasour Mine. Known also as the Gemmill or Nellis mine. It is on lot 10, range twelve, about two miles east of Kirk Ferry station on the Gatineau branch of

the Canadian Pacific railway. The phosphate is found in vein-like bodies in pyroxenite. There are a number of these veins, the greatest width being 15 feet. The length of the principal vein is about 1200 feet. These deposits form a narrow zone of parallel veins or leads that have been worked over a total length of about 2100 feet. The principal vein-filling is pink calcite. First class silver amber mica accompanies the phosphate. The pyroxenite is in contact with gneiss. Pegmatite dikes cut the pyroxenite.

Wilson Mine. This mine is on the south half of lot 13, range sixteen, 3 miles from Cascades station on the Gatineau Valley branch of the Canadian Pacific railway. A large number of phosphate veins have been found, but mining has been confined mostly to one pit, which was sunk to a depth of 80 feet. An eight-foot vein of phosphate is said to have been visible in the bottom of the pit when work was stopped.

TEMPLETON TOWNSHIP

Phosphate has been found in 50 or 60 places in this township, mostly in the northern half. The most important group of deposits is east of McGregor Lake.

McRae Mine. This property is on lots 9, 10, and 11, range five, about a mile east of the Blanche River and four miles from East Templeton station on the Canadian Pacific railway. The existence of considerable bodies of phosphate was proved by diamond drilling, but the depression in prices caused operations to cease before much mining was done. The mine was equipped with electric lights, power having been developed on the Blanche River.

Rainville or Dugas Mine. This mine is on the east half of lot 15, range seven, a mile and a half east of Perkins Mills, and 10 miles from East Templeton on the Canadian Pacific railway. Like many of the mines, it has been worked for both mica and phosphate. There is a small deposit of asbestos on the property. The mine has produced about 2000 tons of phosphate, the mineral having been taken from a number of parallel leads. The greatest depth reached was 70 feet. One lead carries fine-grained phosphate in which deep green fluorspar and amethyst crystals occur.

Phosphate King Mine. This property is about a quarter of a mile from the Rainville or Dugas mine. Both mica and phosphate occur in pocketty leads on the side of a hill. An adit was run into the hillside 100 feet, and a shaft sunk 70 feet. From this a drift was run 280 feet There are many pits and other openings on the property. The mine has produced about 8000 tons of phosphate.

Wallingford Mine. The Wallingford adjoins the Phosphate King on the northwest side. It is a mile and a half from Perkins' Mills and 12 miles from East Templeton station on the Canadian Pacific railway. The mine has been of late years important for its production of mica, but it has yielded considerable quantities of phosphate, about 4000 tons in all. There are still large bodies of phosphate in the mine.

Goldring Mine. On lots 17 and north half of 18, range nine, about 3 miles northwest of the village of Perkins Mills. This mine has been an important producer of phosphate. There are workings on both lots 17 and 18. An open cut in a hillside on lot 18 has been

continued into the hill by a drift nearly 100 feet long. This drift is in a lead, the main filling of which is fine-grained phosphate. This vein is at the contact of a quartz dike with pyroxenite.

Post Mine. This is on the east half of lot 9, range ten, 2½ miles northeast of Perkins Mills. It has produced both mica and phosphate, from veins in pyroxenite, which is in the form of a band in garnetiferous gneiss, cut in places by granite dikes. A considerable quantity of phosphate has been taken out.

Jackson Rae Mine. This property has been extensively worked for both phosphate and mica. It is on the west half of lot 9. range ten, 14 miles from East Templeton station on the Canadian Pacific railway. The most extensive deposit is at a contact between pyroxenite and gneiss. Several thousand tons of phosphate were taken out between 1878 and 1890.

Victoria Mine. This mine, on the west half of lot 15 and the north half of lot 16, range ten, is 2½ miles northwest of the village of Perkins Mills. There are three well-defined leads of high-grade phosphate that have been little worked. The principal product has been mica.

Blackburn Mine. This property includes the north half of lot 7. and lots 8, 9, 10, and 11 range eleven. It is 4 miles north of Perkins Mills. It is the largest mica and phosphate mine in Templeton township. The workings are more systematic than is usual in phosphate and mica mines. On lot 10 is a pit 300 feet long, 180 feet wide, and 120 feet deep, in one end of which is a shaft 160 feet deep. Drifts from 300 to 500

feet long have been run at three levels. Both mica and phosphate were persistent at the greatest depth reached. There are large reserves of phosphate in this mine. The annual production from 1885 to 1892, the period during which the mine was operated for phosphate alone was about 3,000 tons. The total production to 1920 was about 35,000 tons.

Battle Lake Mine. This is on lots 4 and 5, range thirteen, 2½ miles from the Lièvre River. Important bodies of high-grade phosphate exist at several places on this property, which has been operated mostly for mica.

Breckin Mine. This mine is on lots 22 and 23, about a mile west of McGregor Lake. A well-defined lead of phosphate was opened up by a trench 400 feet long and 12 feet wide. A large quantity of high-grade phosphate was produced in the early years of the industry. There are considerable undeveloped showings of the mineral in several places on the property.

Rheaume Lake or King Edward Mine. This property is near the north shore of Rheaume Lake. There are evidences of large deposits of phosphate. At the three main openings a depth of 25 feet has been reached.

WAKEFIELD TOWNSHIP

Wakefield township lies north of Hull township. Its western boundary is a little west of the Gatineau River. Most of the known phosphate deposits are in the southern and eastern parts of the township. Phosphate has been mined at 14 or 15 places in the township.

Haldane or Hughes Mine. This mine was a considerable producer of phosphate from 1878 to 1892. It is on lot 12, range one, about 2 miles west of Wilson Corners. The workings include more than 20 pits, the deepest being 125 feet. The phosphate occurs along a pyroxenite-gneiss contact. The largest vein has a width of over 10 feet. The apatite is mixed with pyrite, large masses of which were sometimes met with.

Comet Mine. The Comet is on the south half of lot 15, range one, about a mile and a half west of Wilson Corners. Large bodies of "sugar" phosphate occur in rather irregular leads or veins in pyroxenite. The first shipment of phosphate produced in Quebec is said to have come from this mine.

McGlashan Mine. This mine is on lot 27, range six, 3 miles north of the village of St. Pierre of Wakefield. It is mainly a mica mine, but phosphate has been taken out as a by-product. The property is capable of producing a considerable quantity of phosphate.

References: Phosphate and Feldspar Deposits of Ontario and Quebec, by H. de Schmid, Mines Branch, Ottawa, Summary Report 1911.

Phosphate in Canada, by Hugh S. Spence, Mines Branch, Ottawa, Publication No. 396.

TALC

The mineral talc is a hydrated silicate of magnesia, and is usually a product of the alteration of other minerals rich in magnesia, such as pyroxene, olivine and dolomite. The purer, light-colored deposits of talc suitable for making talcum powder, etc., are found in dolomite from which the talc has been formed by the

action of siliceous material from intrusions of igneous rocks. The fine-grained, dark-colored deposits are formed by the alteration of such basic rocks as diabase, gabbro, and peridodite, which are converted into serpentine and talc by the influence of igneous intrusions. This massive talc is usually less pure than the white well-crystallized variety, and the impurities make it harder than the pure mineral. The fineness of its grain and its hardness make it useful to saw and carve into table tops, sinks, switchboards, bricks for lining furnaces, etc. The massive variety is sometimes pure enough to grind to a white powder. The lighter colored varieties are used also for making gas light tips and for marking (French chalk). The less pure, fine-grained varieties of talc are generally called **soapstone.** Discoveries of crystallized talc may be looked for in the dolomite of the Grenville series. Massive talc and soapstone may be found wherever highly basic rocks have been subjected to the transforming action of liquids derived from igneous intrusives. As basic lava, gabbro, diabase, and peridotite are fairly common in the Precambrian of Quebec, there should be a good many bodies of soapstone to select from and draw upon.

Canadian pulp mills are using about 2,500 tons of soapstone a year, as lining for the alkali-recovery furnaces. The Quebec stone has been found satisfactory for this purpose.

TALC AND SOAPSTONE IN QUEBEC

Bands of talc and soapstone occur, at a number of points in the Eastern Townships, mostly associated

with serpentine, and in some places with asbestos. No important deposits have been reported in other parts of the Province. The production of soapstone in Canada in 1927 was 1411 tons, the greater part of which was produced in Quebec.

BROME COUNTY

SUTTON TOWNSHIP

Lot 10, Range Five. On the west side of the Sutton Mountain anticline, is a zone of talc and soapstone 20 feet wide at the end of a band of altered serpentine. The talc forms a band on each side of the zone, the material between being soapstone mixed with magnesite and scattered grains of chromite and millerite. The presence of the last two minerals would prevent the use of this deposit for making high-grade talcum powder. The deposit is 3 miles from Sutton station on the Farnham-Newport branch of the Canadian Pacific railway.

Lot 12, Range Seven. Soapstone is exposed in the bed of a creek southeast of the fair grounds at Sutton village.

BROME TOWNSHIP

An impure soapstone occurs near Knowlton.

POTTON TOWNSHIP

Lot 19, Range Five. The deposit is a mile and a half from Travor Road station on the North Troy-Windsor Mills branch of the Canadian Pacific railway. The talc forms a zone of schist about 4 feet wide border-

ing a band of serpentine. Along the opposite contact is a zone of soapstone at least 20 feet wide, that may be of the right quality for furnace lining, etc.

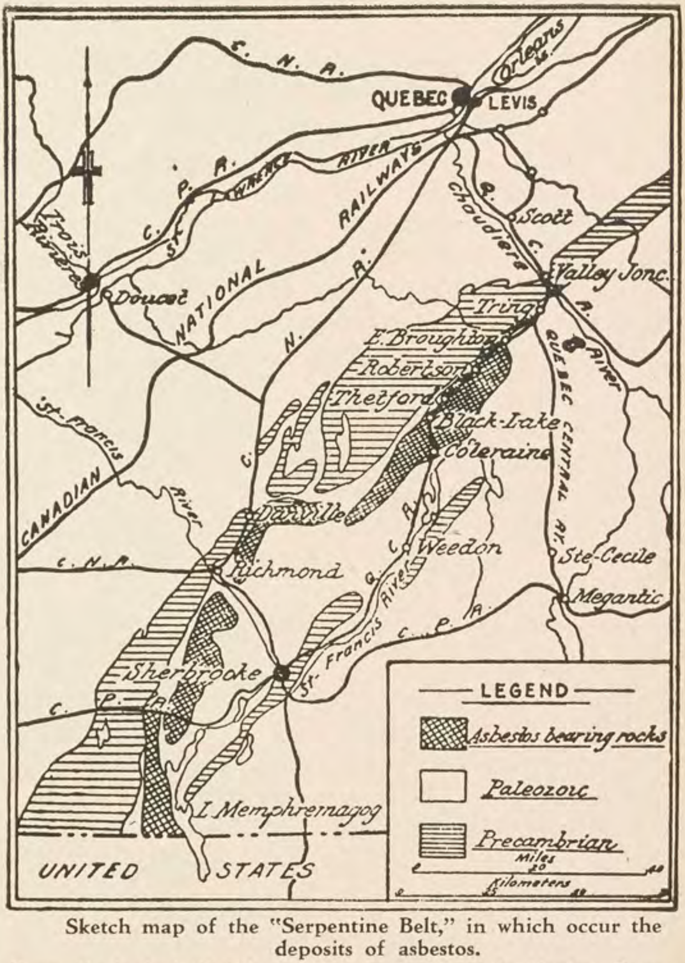
Lot 28, Range Five. An eight-foot zone of talc and soapstone borders a band of serpentine, 2 miles from South Bolton station on the Newport-Windsor Mills branch of the Canadian Pacific railway. The material is probably too much broken for use as soapstone blocks, but it may be useful for other purposes where color is not of importance.

BOLTON TOWNSHIP

Lot 23, Range One. This deposit of talc, the property of John Pibus, is 5 miles southeast of Knowlton on the Sutton-Drummondville branch of the Canadian Pacific railway. The talc forms a zone on the margin of a band of serpentine. The associated rocks are schists and crystalline limestone. The deposit consists of light gray soapstone made up almost altogether of minute scales of talc.

Lot 26, Range Two. This talc deposit is the property of George Pibus. It is about 4½ miles from South Bolton on the North Troy-Windsor Mills branch of the Canadian Pacific railway. The talc is associated with a band of serpentine. It forms a zone of cream-white talc schist ten feet wide and probably several hundred feet long. The quality is high-grade and the deposit may be extensive.

Lot 6, Range Two. On this lot occurs a deposit of soapstone mixed with magnesite, which forms the major part of one side of the zone where the rock passes into dolomite. The whole is bordered by a narrow



Sketch map of the "Serpentine Belt," in which occur the deposits of asbestos.

From *Geological Sketch and Economic Minerals*, Quebec Bureau of Mines.

band of serpentine. A similar deposit occurs on lot 4, range four.

Lot 24, Range Six. This deposit is about a mile and a half northwest of South Bolton station in the North Troy-Windsor Mills branch of the Canadian Pacific railway. The deposit was worked in 1871, when 300 tons of soapstone was taken out and shipped. There are two zones of talc schist associated with dolomite and chlorite. Serpentine is absent. One of these zones is 5 to 15 feet wide and at least 150 feet long. The talc is gray and has a considerable proportion of carbonates. It is therefore low grade, but may be suitable for sawing into blocks of soapstone.

Lot 26, Range Six. Near the northwest corner of the lot is a zone of dark green soapstone with small crystals of magnetite disseminated in it. It borders a band of serpentine. The extent of this deposit may be large. It may be useful for purposes where color is not important.

Lot 17, Range Nine. This deposit is 3½ miles by road from Bolton Centre. It is a zone 20 feet wide bordering a band of serpentine. The talc is dark and is mixed with magnesite. The quantity is probably large.

Lot 1, Range Nine. A band of soapstone about 40 feet wide, associated with serpentine, occurs in a cutting on the Canadian Pacific railway a short distance west of Orford Pond.

RICHMOND COUNTY

MELBOURNE TOWNSHIP

Lot 23, Range Four. The soapstone on this lot forms a band one foot wide. The deposit is about a mile

from Kingsbury station on the Orford Mountain branch of the Canadian Pacific railway. In 1918 and 1920 about 200 tons of the soapstone was taken out by the Canada Paper Company, of Windsor Mills, Quebec.

SHERBROOKE COUNTY

HATLEY TOWNSHIP

Lots 19, 20, and 21, Range Five. It is reported that soapstone of excellent quality occurs over areas of considerable extent on these lots.

WOLFE COUNTY

HAM TOWNSHIP

Lots 22 and 25, Range One. Soapstone is said to occur on these lots near the south slope of Nicolet Lake. It is probably associated with a serpentine mass occupying the basin of Nicolet Lake.

WOLFESTON TOWNSHIP

Lot 20, Range Two. This deposit is on the bank of White River, about 6 miles from Coleraine station on the Quebec Central railway. The talc is dark in color and has small crystals of magnetite disseminated through it. A quantity of this talc was taken out in 1888 and 1889, and ground for use in paints, lubricants, etc.

MEGANTIC COUNTY

IRELAND TOWNSHIP

Lot 2, Craig's Road Range (Range Seven). This property is a mile and a half south of Clapham, and

13 miles by road from Black Lake, the nearest railway station. The deposit is a zone of soapstone about 30 feet wide and at least several hundred feet long. It is associated with serpentine, dolomite, mica schist and greenstone. The material may be of value for cutting into soapstone blocks or for low grade ground talc.

INVERNESS TOWNSHIP

Lot 1, Range One. On this lot is a talc deposit about half a mile south of Clapham post office, and 12 miles northwest of Thetford station on the Quebec Central railway. The deposit consists of a band of soapstone about 80 feet wide with 2 to 6 feet of high grade talc on one side of it. There may be a second zone of high grade talc along the other side of the soapstone. The talc is of excellent quality, and the soapstone is suitable for sawing into blocks and for other uses to which low grade talc may be put. The quantity of both kinds of material may be very large.

THETFORD TOWNSHIP

Lot 12, Range Two. This property, about 4½ miles from Robertson station on the Quebec Central railway, was worked in 1924 and a numbre of carloads of stone were shipped, but it has since been abandoned.

Lot 12, Range Three and Four. The band of soapstone crossing lot 12, range two, continues across this property, on which some stone was quarried in 1925.

Lots 5 and 6, Range Five. The talc deposits on these lots are about a mile from the Quebec Central railway and less than 2 miles from Robertson station on that

railway. They have been opened up by Louis Cyr. The deposits occur in a ridge of serpentine. One zone consists of talc schist 25 to 30 feet wide and more than 200 feet long. A second zone is 12 feet wide. Except for occasional inclusions of serpentine and possibly a little pyrite or pyrrhotite, the talc is pure. With the exception of occasional bands of cream white talc, the material is not suitable for making high grade talcum powder. It is being sawn into blocks for use in the sulphate pulp process.

The serpentine ridge continues eastward across lots 4, 3, and 2. On lot 2, soapstone occurs in a zone 20 feet wide. The material is similar to that being mined on lots 5 and 6. Several cars of cut stone were taken from lot 4 in 1925, and in 1924 two cars of blocks were taken from lot 9.

LEEDS TOWNSHIP

Robertsville Soapstone Quarry Company. This company has been operating since 1925 lot 15, range fifteen, 7 miles from Leeds station on the Quebec Central railway. The stone is a fairly coarse-grained foliated talc, harder than that in Thetford township and it stands handling better. Blocks and bricks are sawn of dimensions required by the sulphate pulp mills, most of which have been using the Quebec stone. The dust formed in sawing is suitable for the manufacture of roofing materials.

BEAUCE COUNTY

BROUGHTON TOWNSHIP

Lot 14, Range Seven. This property is known as the Fraser Asbestos Mine. Along the margin of the ser-

pentine in which the asbestos was mined, there is a zone of soapstone 1 to 2 feet wide and at least 200 feet long. The talc is exceptionally pure, and might be profitably taken out as a by product, if asbestos mining were resumed.

Lot 12, Range Ten and Eleven. A few carloads of cut stone were taken from this property in 1923. It is translucent, fine-grained talc.

VAUDREUIL TOWNSHIP

St. Victor River. This deposit occurs on the north side of St. Victor River about two and three quarter miles west of the Chaudière. It is about 30 feet wide and 1100 feet long. The talc has been derived from dunite at its contact with conglomerate. There are numerous veinlets of magnesite and asbestos in the talc mass. The material is suitable for the manufacture of many talc products, but so far as can be judged by the exposed part, it is too much broken by joints to be suitable for sawing into slabs.

GASPE COUNTY

Veins of light green talc occur in an olivine rock on Ste. Anne River west of Mt. Albert, but the quantity is too small to be important.

References: Talc and Soapstone in Canada, by H. S. Spence, Mines Branch, Ottawa.

Talc Deposits of Canada, by M E. Wilson, Geological Survey, Ottawa, Publication No. 2092.

The Canadian Soapstone Industry, by Hugh S. Spence, Mines Branch, Ottawa, publication No. 687, p. 19.

ASBESTOS

Fibrous varieties of several minerals have been used as asbestos. The material originally employed to make fire-proof cloth, etc, seems to have been fibrous hornblende. In modern times this has been displaced by fibrous serpentine, the fibres of which are not so brittle as those of hornblende, and therefore spin and weave better. Crocidolite, the blue asbestos of South Africa, is a silicate of iron and sodium.

Fibrous hornblende is of frequent occurrence in Quebec, particularly in Grenville crystalline limestone. The fibres are usually too coarse and brittle to be classed as asbestos.

The asbestos for which Quebec is famous is **fibrous serpentine** or **chrysotile.**

Asbestos (serpentine) deposits in Quebec are of two kinds:

1. Deposits of the contact metamorphic type associated with crystalline limestone.

2. Deposits in areas of serpentine that have resulted from regional metamorphosis of peridodite and other rocks high in magnesia.

The first type is not of much importance, as the deposits are small and usually of poor quality. The second type is represented by the asbestos deposits of the Eastern Townships, among the most important in the world. Quebec produces about 80 per cent of the world's supply of asbestos, but 67.5 per cent is made up of the cheaper grades, the average price of which is $24 a ton. The production of spinnng grades amounts to only about half of that of Rhodesia

EASTERN TOWNSHIPS

"The Eastern Townships," is the name commonly used for that part of the Province lying south of the St Lawrence between Montreal and Quebec. The serpentine belt of the Eastern Townships lies along the southeast side of the Sutton mountain anticlinal ridge (generally known as the Notre Dame hills) which enters the Province at the Vermont boundary and continues northeastward through the counties of Brome, Shefford, Richmond, Wolfe, Megantic, and Beauce nearly to the Chaudière River. Asbestos-bearing serpentine has been found from Long Lake, Stukely township, to Broughton, a distance of about 100 miles, but the productive part of the belt is from Danville to East Broughton, a distance of about 70 miles. The basic intrusive rocks forming this belt recur at intervals all the way from the state of Georgia to Newfoundland, but it is only in a few places that the conditions have been such as to favor the development of asbestos. In Quebec, the intrusives include peridotite more or less altered to serpentine, pyroxenite, diabase, gabbro, porphyrite, (poryhyry like diorite in composition) hornblende-granite, and aplite, thus forming a series of rocks ranging from the most basic to the most acidic. The asbestos occurs in best quality and largest quantity in serpentine that has been derived from peridotite. This serpentine is purer than that derived from pyroxenite or from mixed rocks such as peridotite containing a considerable proportion of pyroxenite. In the intrusive masses the rocks are arranged in the order of their densities the heaviest being at the bottom of sills and at the centre of stocks and

batholiths. The order of decreasing densities is peridotite, pyroxenite, gabbro, diabase, and porphyrite. Most of the sills dip towards the southeast, and therefore the rock at the bottom of the sill, peridotite, comes to the surface on the northwest side of the belt. Where the intrusives form a stock or batholith, the best prospecting ground is towards its centre.

The purity of the serpentine depends on its having been formed from a rock composed essentially of olivine. The rock dunite is nearly pure olivine. Peridotite contains small proportions of pyroxene and hornblende, with more or less magnetite, chromite, etc.

Both rocks alter to serpentine that fulfills the conditions for the formation of high-grade asbestos and it is thought that the serpentine of the Thetford type has been derived from these rocks, while that of the Broughton type has resulted from the alteration of pyroxenite. The serpentine can be recognized by its light color, softness, waxy look, and somewhat soapy feel. If the parent rock has contained a good deal of pyroxene, the metamorphosis is apt to have produced considerable talc, which gives the rock softness and soapy feel, not to be confused with the properties of pure serpentine. Rock that owes its softness mostly to talc is not likely to carry good asbestos.

The granite masses are thought to have intruded later than the basic rocks, and to have favored the formation of asbestos in the latter. Therefore the neighborhood of granite in the serpentine masses is looked upon as a good indication.

The question of the depth to which asbestos deposits may be expected to go is an important one. As the

intrusive rocks in which it is found have had a deep origin, it may be expected that the asbestos will continue to at least as great depths as mining is profitable. Diamond drilling at the King Mine, Thetford Mines, proved ore at a depth of 800 feet from the surface.

The serpentine belt forms hills from 1200 to 1500 feet high, but Mount Orford rises to 2800 feet. The belt varies in width from narrow bands less than a mile wide to others five miles in width. The intrusions took place in Devonian times, being earlier in the Broughton than in the Thetford area. In most places the sedimentary rocks that border the serpentine belt are slate, schists, sandstone, and quartzite of Cambrian age.

The asbestos of the Eastern townships is of the chrysotile variety, that is, fibrous serpentine. Two types occur, (1) **cross fibre,** the principal form in Thetford Mines, Black Lake, Coleraine, and Asbestos, and (2) **disseminated** or **slip fibre,** the chief variety in the serpentine of Broughton township in the northern part of the serpentine belt. The **slip fibre** asbestos differs from cross fibre asbestos in the arrangement of the fibres parallel to the walls of the joints or seams in which it occurs.

The cross-fibre type is the most important. The fibres are perpendicular to the direction of the veins, and range in length from microscopic dimensions to as long as five inches. The length of the fibre is sometimes the width of the vein, but more commonly there is a parting, usually marked by a little magnetite, so that the length of the fibre is only

about half the width of the vein. Chromite is associated with this type of asbestos.

Disseminated fibre is scattered through the serpentine without any definite arrangement. The serpentine is softer than that of the cross fibre variety, and the percentage of asbestos is probably more regular. Mining is cheaper than in the cross fibre deposits, but the fibre is usually shorter, and there is no production of "crude," the name given to best asbestos of long fibre. The fibre is not so strong as the cross fibre. There are no deposits of chromite in the slip fibre asbestos deposits, but talc or soapstone is often considerably developed. This mineral does not occur in any important amount in the cross fibre asbestos deposits.

The cross fibre asbestos is characteristic of the Thetford, Black Lake and Danville areas and of smaller intervening areas. It also extends southward, beyond the St. Francis River. The slip fibre variety is characteristiv of the deposts of East Broughton and Robertson, and also of some deposts in Garthby and Tring townships.

Crude asbestos is cross fibre material three eighths of an inch or more in length of fibre. It is hand-cobbed from the run of mine, and then separated into several grades according to length of fibre, tensile strength, and color.

Asbestos fibre includes the shorter fibre asbestos of both types. By a milling process, it is separated from the rock, and graded into a number of products, according to length of fibre.

The prices of the various products in 1928 were as follows:

	Average Per Ton
Crude No. 1	$534.87
Crude No. 2	296.65
Crude run of mine	127.65
Spinning fibre	148.71
Shingle fibre	73.80
Mill board and paper fibres	38.73
Fillers, floats, and other short fibres	14.73

In addition to the asbestos of various grades, the mines produce sands and gravels consisting of crushed serpentine, a cheap by product used for much the same purposes as ordinary sand and gravel.

The total production of all grades in 1928 was 273,-033 tons, valued at $11,238,361. To produce this amount, 5,159,247 tons of rock was mined. The asbestos therefore constituted 5.3 per cent of the rock mined. The three grades of "crude" together make up only 1.5 per cent of the total product, but account for over 12 per cent of the total value.

In 1927, mines were operated in the townships of Broughton, Thetford, Ireland, Coleraine, Tingwick, and Shipton. The method used has been mostly open cut, but underground mining has been successfully practised. It was first undertaken at the Thetford Mine of Consolidated Asbestos Limited.

Uses. Asbestos of the various grades has a great many uses and its use is constantly extending. The spinning grades are made into firemen's suits, mitts for furnace workers, etc. The lower grades are used for the manufacture of shingles, sheeting, roofing paper, cement, insulating packings of various kinds,

wall boards, etc. In the automobile industry, asbestos is used in making brake linings and clutch facings.

The number of asbestos properties that have been worked from time to time is large, and their activity depends in part on the state of the market for the products. In the following short descriptions the principal properties active in 1928 are grouped under the names of the townships.

THETFORD TOWNSHIP

The **King Mine** is on lots 26 of ranges five and six, Thetford township, at Thetford Mines, Megantic county. It is one of the earliest asbestos mines worked in Quebec, and is the largest and deepest worked by the quarry method, having a surface area of about 25 acres and a depth of 375 feet. A prospect tunnel about 275 feet from the surface has shown pay ore for a length of 500 feet from the face of the quarry. Diamond drilling has shown good ore to a depth of 800 feet from the surface.

The **Johnson Mine**, on lot 27, range six, Thetford township, at Thetford Mines, is operated by the quarry method.

The **Bell Mine**, on NE½ of lot 27, range five, Thetford township, at Thetford Mines, is one of the oldest asbestos mines. It adjoins the King Mine on the northeast and the Johnson mine on the south. It is worked by the quarry method, the quarry being 900 by 500 feet in area and 160 feet deep.

The **Thetford Mine** is on lot 28, range six, Thetford township, at Thetford Mines. It is now worked by un-

derground mining, with stopes 35 feet wide and over 260 feet long.

COLERAINE TOWNSHIP

The **Beaver Mine** is on lots 31 and 32, range C, Coleraine township, at Thetford Mines. It is worked by the quarry method, the quarry having a surface area of about 1100 by 500 feet, and a depth of 245 feet. A prospect tunnel was run westerly from the quarry face about 160 feet from the surface and showed ore throughout its length. Good ore was also found by diamond drilling to a depth of 500 feet from the surface.

The **Maple Leaf Mine** is on lot 29, range A, Coleraine township, between Thetford Mines and Black Lake. It is operated by the quarry method, the pit being 600 by 500 feet in area and about 160 feet deep.

The **Johnson Mine** is on lot 27, range B, Coleraine township, at Black Lake. The quarry method is used.

The **Paré Mine** is in blocks A and B, Coleraine township. It is worked by the quarry method, and the ore is all milled without previous sorting out of the crude fibre.

The **British Canadian Mine** is in block A, Coleraine township, near Black Lake. It is worked by a number of glory holes from which the ore descends into pockets along a system of tunnels nearly a mile long. The ore reserves are very large.

IRELAND TOWNSHIP

The **Vimy Ridge Mine** is on lots 23, 24, and 27, range three, Ireland township, Megantic county. This mine has been worked by the quarry method.

SHIPTON TOWNSHIP

The **Jeffrey Mine** is on lots 8 and 9, range three, Shipton township, Richmond county at Asbestos. It is worked as a quarry nearly circular in shape. About 100 acres is under development.

BROUGHTON TOWNSHIP

The **Boston Mine** is on lot 13 e, range four, Broughton township, Beauce county, about 1½ miles from East Broughton. It is worked as a quarry. The ore is all of the "slip fibre" kind and is all milled, without any recovery of crude fibre.

The **Ling** or **No. 1** and the **Eastern Townships** or **No. 2** are at East Broughton on lots 12c, 43b, and 13e, range six, Broughton township, Beauce county. They are both operated as quarries, the Ling being 950 by 350 feet and about 125 feet deep, and the Eastern Townships about 500 by 210 feet and 75 feet deep. They are separated by a narrow wall of ore which will eventually be taken out. The ore is of the "slip fibre" kind.

Serpentine occurs in a number of areas outside of the Eastern Townships, but in none of them so far as investigated has asbestos of good quality been formed in quantity sufficient to make profitable mines. Descriptions of a number of these outlying areas are added.

GASPE

There is a small area of serpentine at Mount Albert near the headwaters of Ste. Anne River, and another at Mount Serpentine near Dartmouth River. Asbestos occurs in places in the Mount Serpentine area, and in

one prospect pit, fibres up to seven eigths of an inch in length were found. The amount, however, is small, and as the serpentine belt is only two miles long and less than half a mile wide, the outlook for discovering workable deposits does not seem bright.

CHIBOUGAMAU

Chibougamau Lake is about 160 miles northwest of Lake St. John A belt of serpentinized peridotite crosses Asbestos Island in this lake, and extends to the mainland. The small size of the serpentine masses is not favorable to the occurrence of merchantable asbestos in commercial quantities. Exploration has shown considerable amounts of fibrous material, but it is mostly of the brittle variety called **picrolite.** No. 1 fibre is rare, and the maximum length observed is two thirds of an inch. Further exploration may show up something better.

TRECESSON TOWNSHIP

This township is in Abitibi County, and is crossed by the Canadian National railway. On lots 2 and 3, range five, is a ridge of peridotite partly changed to serpentine. Veinlets of asbestos occur, mostly in the serpentine. They are, however, very scattered, and do not average more than a quarter of an inch in width. A little slip fibre, two inches long, occurs, but so far as developed, the quantity of asbestos is not of economic importance. The property is half a mile north and 2½ miles west of Vilmontel village.

OTTAWA DISTRICT

Chrysotile asbestos occurs at a number of places north of the Ottawa River associated with crystalline

limestone of the Grenville series. Rounded masses of serpentine of a light green, yellow green, or dark green color are distributed irregularly through the limestone. The asbestos forms part of these masses, usually forming their outer coating. It is sometimes of good quality, yielding a fine fibre with good spinning quality but rather short, being rarely more than half an inch. The quantity of rock carrying a sufficient percentage of asbestos is usually small, but at some places in Templeton and Denholm townships, mining seems to have been carried on with profit. There is a possibility that an exceptionally large and important deposit of commercial asbestos may be found in the Grenville crystalline limestone.

The most interesting deposits so far found are in the townships of Templeton, Wakefield, and Denholm north of Ottawa. Asbestos has also been found in the townships of Portland, Cawood, Wentworth, and Mulgrave. A little can usually be seen in the bands of crystalline limestone wherever serpentine has been developed. This has usually taken place in the vicinity of dike-like masses of pyroxene, as in the case of mica and phosphate deposits. As with these minerals also, there is usually an intrusion of acid pegmatite and other granite rocks not far away.

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CHAPTER XIII

NON-METALLICS (Cont'd.)

BARIUM, STRONTIUM, LITHIUM, MAGNESIUM

BARIUM

The metal barium is a rather soft, gray metal, very easily oxidised and not of importance commercially. The most important barium minerals are the sulphate, **barite**, and the carbonate, **witherite.**

Barite

The common filling of veins is quartz and calcite. Less common fillers are fluorspar, barite and celestite. These materials may therefore be found wherever there are veins. They may be mixed or occur in veins mainly filled with quartz or calcite. Veins of barite, celestite, or fluorspar may carry valuable metallic minerals and thus become ores of lead, zinc, copper, etc. Other names for the mineral are **barytes** and **heavy spar.** The chemical name is **barium sulphate,** indicating its composition, the metal barium with sulphur and oxygen.

While barite veins are plentiful and widespread, as in the case of other valuable minerals it is only the exceptional vein that can be profitably mined. One

of the important uses of barite is as a constituent for white paints. For this purpose it must be free from all minerals that would destroy the purity of the white, when ground to a very fine powder. This requirement cuts out barite veins that carry considerable quantities of pyrite and other sulphides.

Uses of Barite. Ground barite is used as a filler in paper, cloth, oil-cloth, rubber, linoleum, etc. and as a substitute for white lead in making white paint. In the manufacture of enamelled paper, ground barite is used as filler and also for surfacings. It is used as a filler in the manufacture of artificial ivory and in many other materials where a crystalline body of material is required. Barite has the advantage of its chemical inertness, making it not liable to any change. It is useful as an addition to certain kinds of glass, enamel, and glaze. For the manufacture of ground barite, manufacturers prefer the soft, very fine-grained variety.

Lithopone is a white paint material made from barite by passing it through a chemical process that gives as a final product a mixture of about 70 per cent barium sulphate and 30 per cent zinc sulphide. Part of the zinc sulphide may have been changed to zinc oxide. All these substances are pure white when not mixed with anything colored. Lithopone is extensively manufactured for white paint, as a rubber filler, etc, and is sold under a good many other trade names. The hard, crystalline barite can be used for this manufacture, even when stained with iron rust, as the chemical process eliminates this.

Barite is used as the starting point in the manufacture of a number of barium chemicals, such as **blanc fixe,** artificial barium sulphate of the same composition as barite, but purer and finer grained, **barium carbonate,** used in the manufacture of optical glass, enamels, etc, and many other barium chemicals.

BARIUM IN QUEBEC

The carbonate of barium, **witherite,** has not been reported to occur in the province, but the sulphate, barite or barytes, has been found in a number of places.

HULL COUNTY

Hull Township. On lot 7, range ten, about 5 miles from Ironside station on the Gatineau branch of the Canadian Pacific railway is a barite vein in crystalline limestone. The vein is 3 to 4 feet wide and has been worked by open pit for a length of 350 feet and to a depth of 60 feet. A considerable tonnage has been shipped. The barite is soft and of a good white color. A good deal of it is mixed with pale green fluorspar.

Barite occurs in several other places in this township, but the known deposits are not of economic importance.

Templeton Township. A number of barite veins have been found in the northern part of this township, but they are too small to be of economic importance. On the north half of lot 13, range thirteen, near Little Dam Lake, is a narrow vein of coarsely crystalline barite of a blue color. Considerable quantities of **rutile**

occur both in the barite and in the calcite bordering the vein.

PAPINEAU COUNTY

Buckingham Township. On lot 21, range four, 5 miles from Angers station on the North Shore line of the Canadian Pacific railway, are six or more parallel veins of barite in crystalline limestone, forming a zone about 100 feet wide. The veins are narrow. With the barite is a considerable proportion of galena, which attracted attention a good many years ago. Zinc blende is also present, in smaller amount. The presence of these sulphides probably makes the deposit of little importance as a source of barite.

PONTIAC COUNTY

Onslow Township. Near the village of Quyon and one mile from Quyon station on the Pontiac branch of the Canadian Pacific railway, is a series of narrow, parallel barite veins in Ordovician limestone. Outcrops occur over a length of 300 feet, but the barite is mostly in mere stringers. The deposit does not appear to have economic importance.

BONAVENTURE COUNTY

At Port Daniel and along streams flowing into Gaspé basin, there are barite veins in limestone, but none of economic importance have been discovered.

Reference: Barium and Strontium in Canada, by Hugh S. Spence, Mines Branch. Ottawa, publication No. 570, p. 56.

STRONTIUM

Strontium is a metal closely allied to calcium, the metal of which lime is the oxide. Barium is the third metal of this group. They are all rather soft, gray metals, very easily oxidised, and therefore by themselves not useful as metals. Strontium has been used as a hardener of copper castings.

The principal strontium minerals are **celestite,** the sulphate of strontium, and **strontianite,** the carbonate of strontium. Celestite is the commoner mineral, and is by far the most important source of the world's supply of strontium minerals. Strontianite brings a higher price because it contains a higher percentage of strontium oxide, and because it is more easily converted into the commercial products.

Celestite is a soft, rather heavy mineral, white creamy, or pale blue in color. It is much like barite but not quite so heavy. Its crystals are sometimes long and arranged in such a way as to give the mass a somewhat fibrous appearance. It occurs in veins, sometimes with calcite, fluorspar, barite, and metallic vein minerals. Celestite may contain more or less barite crystallized with it. When the amount is considerable, the mineral is called **barytocelestite.** The mixed mineral is not so valuable as pure celestite, and if the percentage of barite is high, the mineral may be unsaleable.

Strontianite is a white, yellow, or greenish mineral, usually in masses of crystals having a radiated, columnar, or fibrous appearance. It is a soft and rather heavy mineral.

Celestite and strontianite are the raw materials for the manufacture of a number of strontium compounds, including strontium hydrate, used in the manufacture of beet sugar, strontium nirate for making red lights for fireworks and signal flares, and a number of chemicals. Celestite has been used instead of barite (barytes) as a filler and in the manufacture of lithopone. Strontium carbonate is used in the manufacture of iridescent glass. The use of the metal strontium for hardening copper castings has been carried out either by adding it to the fused copper or by generating it from fused strontium chloride using the melted copper as a cathode in which to deposit the strontium.

The market prices for the strontium minerals are (1928), for celestite \$15 to \$18 a ton, and for strontianite \$25 to \$35 a ton.

Strontianite is a rare mineral, and there are very few economic deposits known in the world.

No strontium minerals in important quantities have been found in Quebec.

LITHIUM

The metal lithium is related to sodium and potassium. It has so far not assumed any economic importance, but a number of its compounds have been made useful in medicine, and some of the lithium minerals have found applications in the manufacture of glass. As the lithium minerals are not often found in commercial quantities, a workable deposit is valuable. **Lepidolite** or **lithium mica** resembles the commoner varieties of mica, but is more brittle, and is usually of a pink, rose-red, violet, lilac, or yellow color.

It is sometimes gray, grayish white or white. It is found in dikes of pegmatite granite. Two other lithium minerals, **amblygonite** and **spodumene** are also found in pegmatite dikes, and sometimes in gneiss. As these rock formations are plentiful in the Precambrian of Quebec, the chances of finding workable deposits of lithium minerals in this province should be good. Amblygonite and spodumene have been found in economic quantities in Northern Manitoba. A deposit of lepidolite was mined as mica a number of years ago near the Gatineau River. It proved too brittle for use as mica. Amblygonite and spodumene might be easily overlooked in a pegmatite dike as they are often of an inconspicuous gray or whitish color. Spodumene is sometimes green, yellow or purple. The lithium minerals sell for $20 to $30 a ton.

LITHIUM IN QUEBEC

HULL COUNTY

In Wakefield township, Hull county, there is a deposit of lepidolite or lithium mica on the south half of lot 25, range VII. The nearest railway station is at Diotte on the Gatineau branch of the Canadian Pacific railway, 12 miles west of the mine, generally called the LeDuc Mine. The deposit was mistaken for ordinary mica and the true nature of the material was only discovered after considerable work had been done on the property.

The lepidolite occurs in a pegmatite dike that intrudes garnet-gneiss and quartzite. It is of a gray

bronze color, and is found in pockets as large flakes or "books" up to 1 or even 2 feet in diameter, and 1 to 2 inches thick. This is a unique occurrence of lepidolite, the mica in other places being in small flakes and of a lilac or pink color.

Several tons of the mineral were taken out in the course of mining for green tourmaline of possible jewel quality. The workings show evidence of considerable quantities of lepidolite, and further development may show that the deposit is of economic importance. This lepidolite contains 5.44 per cent of lithium oxide.

UNGAVA

Spodumene and amplygonite are reported to occur in a pegmatite dike on Walrus Island, Paint Hills group, on the east coast of James Bay.

MAGNESITE AND MAGNESIUM

Magnesite is carbonate of magnesia. When pure, it is a white mineral, much like calcite, but harder and a little heavier. One variety shows no crystalline structure and looks much like a piece of broken porcelain, but it is not so hard.

Magnesite is found in serpentine, talc schist and other varieties of metamorphic rocks, and also in dolomite.

It is used largely for making magnesia bricks. Magnesia is the oxide of magnesium. In commerce it is often called magnesite. It is made by heating mag-

nesite to drive off the carbon dioxide. This is the same kind of process as making lime from limestone, but the temperature required for decomposing the limestone is much higher. Magnesia bricks are used for lining electric, basic-steel, copper smelting, and other furnaces; also for sulphite pulp manufacture, fireproof flooring, and for making magnesia medical and chemical materials. Magnesite is the raw material for the manufacture of the metal magnesium.

MAGNESITE IN QUEBEC

EASTERN TOWNSHIPS

Magnesite occurs at several points in the serpentine belt of the **Eastern Townships.** On lot 17, range IX, Bolton township, is a deposit said to be 60 feet wide. An analysis gives 83.35 per cent of magnesium carbonate, 9.02 per cent of carbonate of iron, and 8.03 per cent of silica. It is too high in silica and iron to be useful for lining electric furnaces. Another deposit on lot 24 has also an objectionably large percentage of impurities. In Sutton township, range VII, lot 12, is a deposit a foot wide, in mica schist. It is very impure, in places containing as much as 46 per cent of insoluble matter.

ARGENTEUIL COUNTY

The magnesite deposits in **Grenville** and **Harrington** townships, Argenteuil county, are in crystalline limestone areas, where dolomite has been altered by the influence of intrusive masses of gabbro, and other basic and intermediate rocks. Where the dolomite has

been thus affected, it carries serpentine, talc, pyroxene, mica, etc. The rock varies in composition from dolomite to fairly pure magnesite. As dolomite dissolves more freely than magnesite in rain water, the weathered surface of the rock is pitted where the proportion of dolomite is considerable. This magnesite is crystalline, and thus differs in appearance from the dull, parcelain-like magnesite found in Austria.

The Argenteuil county magnesite carries 8 to 9% lime. It is free from iron, and so has not the slight sintering property necessary in the manufacture of magnesia bricks. This is remedied by adding a small percentage of blast furnace slag or iron mill-scales.

The **International Magnesite Company Ltd.** has a quarry and calcining kiln on lot 13, range I, Harrington township. The magnesite is shipped partly as mined (crude magnesite), and partly as calcined magnesite (magnesia). The deposit is composed of crystalline magnesite in a band of magnesian limestone. Serpentine forms one wall, and there are occasional patches of green serpentine in the magnesite.

The **Scottish Canadian Magnesite Co., Ltd.**, and the **North American Magnesite Producers, Ltd.** operate jointly quarries and mill on lots 15 and 18, range XI of Grenville township.

In 1927, the production of magnesite in Quebec was valued at $230,309, and in 1928 at $346,991.

References: Geological Survey of Canada. New Series, Vol. XIII, 14-19R; Vol. VII, 95S; Vol. IV, 111 R. Also reports of the Department of Mines, Province of Quebec.

CHAPTER XIV

NON-METALLICS (Cont'd.)

PRECIOUS AND SEMI-PRECIOUS STONES

Gem stones. Precious stones are mostly crystallized minerals, and each gem is usually made from a single crystal or part of a crystal. The mineral must be hard enough to be durable and keep its polish under wear. While some gem stones are opaque, the majority are transparent, and any cloudiness, cracks, or inferiority in color may lower their value or make them valueless as gem stones. The conditions for the growth of good crystals, such as slow cooling, the presence of mineral solvents to keep the mass liquid, and the formation of small cavities into which crystals could grow without too much crowding **(vugs** or **geodes)** have been present during the formation of many of the crystalline rocks of Quebec and probably in the earlier ages gem stones were formed freely. But the folding, re-heating, and crushing that have since taken place, must have destroyed the perfection of most crystals of gem quality. Pegmatite dikes are the home of a large variety of precious stones, including ruby, sapphire, beryl, (emerald, aquamarine) chrysoberyl (alexandrite, chrysolite, cat's eye), phenacite, topaz, garnet, tourmaline, zircon (hyacinth or jacinth), and sphene.

The weight of gems is given in terms of a special unit, the **carat,** which is very nearly equal to 3⅕ grains. One ounce Troy equals 151¾ carats very nearly.

In describing gem stones or **precious stones** some are included that are less valuable and that are usually classified as **semi-precious stones.**

Amazonstone. Also called **amazonite.** The variety of feldspar, **labradorite,** is called by this name when it is of a fine blue color that changes as the stone is turned, the **chatoyant** effect. Another feldspar, **microcline,** has been found of a fine green color. The labradorite variety of amazonstone is found in large quantities in the Hamilton River district, Labrador, and the same formation extends westward into Quebec. The mineral is especially conspicuous on the northeast side of Lake Michikaman, on the islands in Lake Ossokmanuan, and along the Romaine River.

It also occurs in several places in Hull county. The microcline variety is found in fine cleavable masses in pegmatite veins on some of the islands of the Paint-Hills group, east coast of James Bay. (See Geological Survey of Canada, New Series, Vol. XII, p. 19R). The amazonite of the Le Duc mine, Wakefield township, Hull county, is probably microcline. The greenish amazonstone of the Villeneuve mica mine, Labelle county, is also microcline.

Agate, see **Quartz**
Alexandrite, see **Chrysoberyl**
Amethyst, see **Quartz**
Aquamarine, see **Beryl**
Aventurine, see **Sunstone**

Beryl. This is a silicate of aluminum and beryllium. The color of the crystals is usually green, but beryls of blue, yellow, rose-red and white shades are found. Clear green crystals of gem quality are called **emeralds.** Blue-green crystals are used as gems under the name **aquamarine.** Beryl crystals are six sided prisms. The hardness is greater than that of quartz. Beryl is found in pegmatite dikes and in the rocks intruded by them. Valuable beryl crystals have been obtained as a by-product in mining white mica, but so far crystals of gem quality have not been found in Quebec. The frequent occurrence of opaque crystals (See p. 165) leads to the hope that transparent crystals may be found.

Cairngorm, see **Quartz**

Cat's Eye, see **Chrysoberyl**

Chrysoberyl. This is an oxide of aluminum and beryllium. Jewellers call the yellow variety **chrysolite,** but mineralogists apply this name to olivine. The green variety is valued as a gem and is called **alexandrite.** A green variety that shows the peculiar play of colors described as **chatoyant,** is called **cat's eye.** Chrysoberyl is very hard and the crystals are apt to be tabular. It is found in pegmatite dikes and in rocks in contact with them. Crystals have been found about a mile below the forks of the Rivière du Poste, a branch of the Matawin River (Am. Jour. Sci., 1905, XIX., 316).

Chrysolite, see **Chrysoberyl** and **Olivine.**

Corundum. This is oxide of aluminum, found in rocks of the granite type, such as syenite and nephe-

line-syenite, also in anorthosite, peridotite, serpentine and other basic igneous rock. The jewel varieties of corundum are **ruby**, clear crystals of a red colour, and **sapphire**, blue corundum crystals. To be of value the crystals must be transparent and free from cracks and other flaws. In New York and New Jersey, rubies have been found in crystalline limestone. In North Carolina they have been found in an olivine dike, the olivine being partly altered to serpentine. In Burmah, long the producer of the finest rubies, they are found in crystalline limestone and gneiss. Sapphires have been found in crystalline limestone and in andesite. Crystals of these gems can be recognized by the six-sided prismatic shape, and by their great hardness. They easily scratch quartz crystals. No corundum crystals of gem quality have been found in Quebec. They should be watched for in crystalline limestone and gneiss so plentiful in the province.

Diaspore, a hydrated oxide of aluminum, is sometimes found with corundum. It is about as hard as quartz or a little softer. The crystals are commonly colorless, but sometimes yellowish like topaz or brownish.

Diamond. The diamond is carbon crystallized under conditions not fulfilled in furnaces and fires. Graphite is also crystallized carbon, and it can be made artificially from coke by intense heating. Microscopic diamonds have been made by sudden cooling of intensely heated carbon under certain conditions, but all attempts to make diamonds of gem size have so far failed. The natural stones are found in peridotite and serpentine, and in the soft material that results from the weathering of these rocks. In Brazil they

are found in a peculiar flexible sandstone, **itacolumite.** Diamonds of gem size have been found in the glacial drift in Wisconsin. On account of their great hardness and durability, diamonds survive longer than other minerals the wear and tear of the ages. They should be watched for in panning. Microscopic diamonds have been reported to occur in the chromite of Black Lake, but this has not been confirmed.

Diopside. This is a variety of pyroxene, sometimes found in fine emerald-green crystals of value as gems. They may occur in crystalline limestone or in the pyroxene rock often associated with it in the province of Quebec. Crystals not of gem quality have been observed in limestone at Calumet Falls, Pontiac county.

Fluorspar. When in large, clear masses of a fine color, fluorspar is of value as an ornamental stone, for making vases, etc. As it is only one degree harder than calcite it is easily worked. On the other hand it is not hard enough to be very durable. Fine green crystals occur in some of the mica mines north of Ottawa. Masses large enough to be of value for ornamental purposes have not been found.

Garnet. Garnet crystals are sometimes perfect and clear enough to be of value as gems. Most of the varieties of the mineral are used as gems when transparent crystals are found. Jewelers use red and yellowish brown garnets under the name **hyacinth.** The smaller crystals are used as jewels in the movements of watches, but the harder crystals of ruby and sapphire are preferred. Dark red garnet of gem quality has been found in the garnet quarry in Labelle County,

two miles south of Labelle station on the Montreal—Mont Laurier branch of the Canadian Pacific railway. Crystals of a yellowish tint are reported from Wakefield township. They are of gem quality. Green chrome garnet of gem quality has been found as small crystals in Orford township, Quebec, in vugs in crystalline limestone. Gem garnets are found in serpentine. Very fine gem garnets have sold for as much as $50 each. Good crystals of one carat weight have been valued at $1 to $5 each.

Hyacinth, see **Garnet** and **Zircon.**

Jade, also called **nephrite,** is a silicate of calcium, magnesium and iron. Green varieties of pyroxene and hornblende are included under this name.

Jasper, see **Quartz.**

Moonstone, or peristerite, is the name given to the varieties of feldspar, albite and orthoclase, when they show the chatoyant play of colors, usually delicate shades of blue and green. Fine specimens have been reported from Buckingham township, and from the Villeneuve mica mine, where considerable quantities occur.

Olivine, see **Peridot.**

Peridot is the jeweler's name for olivine crystals. Olivine is a silicate of magnesium and iron, usually of a green color. The crystals may be found in basic igneous rocks and in some kinds of dolomite.

Peristerite, see **Moonstone.**

Perthite. This is an ornamental stone that owes its beauty to parallel layers of two feldspars, orthoclase and albite. The layers give the internal reflec-

tions of light characteristic of aventurine or sunstone. The mineral takes its name from the town of Perth, Ontario, near which it was first found. There it is flesh-colored, but it has been found of other colors. It occurs in the Le Duc mine, Wakefield township, Hull county.

Phenacite, a silicate of beryllium, may be looked for in pegmatite dikes. It forms colorless crystals, very brilliant. It looks a good deal like quartz, but is harder, and the crystals are of a different shape. (See Handbook for Prospectors p. 297). It has been found in small crystals in Témiskamingue county at the Kewagama River in pegmatite dikes.

Quartz. A good many varieties of quartz are used as jewels and ornamental stones. Clear, colorless, flawless quartz crystals of sufficient size are ground into spheres which when large are valued at thousands of dollars. Necklaces and other jewels are made of quartz crystals cut under the name **rock crystal**. The United States Navy offers $6,000 a ton for perfect quartz crystals weighing not less than 2 pounds each. They must be transparent and free from cloudiness, cracks, and spots. They are used for controlling the frequency of radio transmitters. Pink to purple crystals are used under the name **amethyst**. Smoky crystals are used as **cairngorm**. **Sagenite** or flêche d'amour is quartz crystals penetrated by fine needles of rutile. These and other varieties of crystallized quartz are found in pegmatite granite and other acid rocks. They are to be looked for in vugs (geodes) in those rocks. Cavities in sandstone and quartzite have yielded very fine crystals of quartz. **Agate** of good quality has rare-

ly been found in Quebec. Agate pebbles are found in the conglomerate of Bay Chaleur, Gaspé county. **Jasper** is a variety of quartz usually of a red color. On the River Ouelle it is associated with **chalcedony,** another variety of quartz. Bright red jasper is sometimes set in a white mass of quartz making a very pretty combination. Large quantities of rich red jasper are found in Hull township. Blood-red jasper, often finely clouded, occurs near Sherbrooke.

Rock Crystal, see **Quartz.**

Ruby, see **Corundum.**

Star quartz or **quartz asteria** is a variety of clear, transparent quartz that when cut in a certain way shows a six-rayed star. Quartz of this variety and of gem quality has been found in the Villeneuve mica-feldspar quarry, Labelle county. **Quebec diamonds,** so-called, are crystals of quartz, found plentifully at Cape Diamond. They are often cut and polished for gems.

Sagenite, see **Quartz.**

Sapphire, see **Corundum.**

Scapolite, a silicate of alumina, lime, and soda, occurs in fine yellow masses in Grenville township.

Serpentine is a hydrated silicate of magnesium. When of a rich green or greenish yellow color, it is of value as an ornamental stone, although its softness makes it of inferior durability. It can be used only for interior decoration as its polished surface soon weathers when exposed out of doors. Serpentine occurs in large quantities in the Eastern Townships, and in other parts of the province. It has been

quarried for ornamental purposes in Grenville and Templeton townships. It has been found difficult to get large blocks free from flaws, but slabs of considerable size and rich coloring have been taken out.

Sodalite. This is silicate of aluminum and sodium with sodium chloride. It varies in color, but the deep blue variety is sought for ornamental purposes. Small quantities have been found in the rocks of Mount Royal and other localities in the province, but none of commercial value.

Sphene or **titanite** is calcium titanium silicate. When found in transparent crystals it is prized as a gem. Fine crystals have been found in the townships of Buckingham, Hull, Templeton and Wakefield.

Spinel is an oxide of magnesium and aluminum. Some varieties contain iron or chromium. The common color of gem spinel is ruby red, but other colors may give value to good transparent crystals. The crystals are usually octahedrons of the cubic system. Ruby spinel is sometimes found with the true ruby, the crystals of which are six-sided prisms. Spinel is found in crystalline limestone, serpentine, peridotite, etc. Small, translucent crystals of spinel, of a fine blue color, have been found in crystalline limestone, in the Seigniory of Daillebont, Joliette county.

Sunstone or **aventurine** is a variety of feldspar showing peculiar fiery reflections probably due to small crystals of hematite, etc. A variety of quartz showing this effect is also called aventurine.

Tourmaline is a silicate of complex composition. The common color is black. When in fine clear crystals of

a pink, red, or green color, it is of value as a gem. Tourmaline crystals can be recognized by their triangular cross section. They are usually more or less distinctly grooved lengthwise. The crystals are to be found in pegmatite dikes and at the contact of intrusive granite with such metamorphic rocks as gneiss, schists, and crystalline limestone. Green and red tourmaline of gem quality occurs in the Le Duc mine, Wakefield township, Hull county. An attempt was made to mine the material as gems, but the greater part was found to be cloudy and fractured. The tourmaline occurs with lithium mica (lepidolite), and the part of gem quality might be sorted out, if the mine were worked for the lithium mineral. Fine tourmaline crystals have been found at Hunterstown, Maskinonge county; at Calumet Falls, Litchfield township, Pontiac county; and at Clarendon, Pontiac county.

Zircon is silicate of zirconium. Zircon crystals are usually of an opaque brown color. They can be recognized by their square cross section and by their hardness, a little greater than that of quartz. Clear crystals of a rich red color are used as gems under the name **hyacinth** or **jacinth.** Orange or brown crystals when transparent may be of value. Crystals suitable for gems may be found in pegmatite dikes and at contacts of igneous intrusives with metamorphic rocks, particularly crystalline limestone and nepheline syenite. Zircon crystals occur at many localities in Quebec, as in Grenville township, in the apatite deposits of the Buckingham district, and in the muscovite deposits of Saguenay county; but, so far, crystals of gem quality have not been found.

CHAPTER XV

NON-METALLIC MINERALS (Cont'd)

SALT, GYPSUM, PETROLEUM AND NATURAL GAS, HELIUM, COAL, CLAY.

SALT

Salt has the chemical name **sodium chloride**, which indicates its composition. Its common uses are too well known to require description. One point, however, in connection with its use in food merits attention. The natural sea salt has mixed with it small quantities of iodine compounds that are a necessary constituent of our food. These materials are removed in the process of refining the salt. Their absence from table salt does not matter for those living near the sea board, where all the food is apt to be well seasoned with natural salt and even the air carries it as dust. But people living far inland, and particularly those in regions where the rocks are either igneous or very old sedimentaries that have lost all traces of salt that they may have acquired from the ocean, may suffer from diseases like goitre due to deficiency of iodine in the food. Since this has been realized, manufacturers of table salt usually add

enough potassium iodide or other iodine salt to their products to make up the deficiency.

Salt is the raw material for a large number of important chemical manufactures, including soda (caustic and carbonates), sodium, chlorine, chloride of lime, and many others.

Salt is found in economic quantities only in those sedimentary rocks that have not undergone much, if any, metamorphism, and are still lying approximately in the horizontal layers in which they were formed. It is believed that the salt has been deposited by the evaporation in a dry climate of parts of the ocean barred off from the main body by some change in the bottom. Gypsum and other constituents of ocean water are often found associated with layers of **rock salt**, as the solid natural salt is called. (See **Gypsum** p. 296). But it is believed that some bodies of rock salt as we find them now have been deposited by the slow leaching and transportation of older salt deposits.

Salt springs are natural brines that may be (1) sea water imprisoned by geological changes, (2) solutions formed by ground water working on beds of rock salt, or (3) solutions of salt made by the slow collection of salt from the sedimentary rocks and its concentration by slow evaporation. It is thus seen that salt springs may or may not be a sign of underlying beds of rock salt.

Rock salt deposits have been found in sedimentary rocks of all ages from recent back to the Silurian period. Salt brines have been tapped in drilling wells in even older rocks, but these may have been derived from rocks higher up in the geological scale.

No deposit of rock salt has so far been discovered in the Province. Salt springs are known but the brine is not suitable for the manufacture of salt. In drilling for oil and natural gas in Gaspé large quantities of salt water were encountered in many of the wells. Salt water was found in a well drilled for gas at St. Gregoire, Nicolet county. The salt water was struck at 605 feet.

GYPSUM

Introduction.—Gypsum is sulphate of lime crystallized with water. When it is carefully heated so as to deprive it of the greater part of its water but not all of it, it is converted into plaster of Paris. When this is mixed with the right quantity of water, it becomes gypsum again, and in the act forms a mass of small crystals. This is the "setting" of plaster of Paris, the property upon which its usefulness depends. Gypsum, when pure, is white. It is soft enough to be scratched by the finger nail. It is often massed in crystals so small that it looks a good deal like chalk, but usually, in a bright light, the glistening surfaces of small crystals can be noticed. Sometimes single crystals have grown so large that they form masses as clear and transparent as glass These have a special name, **selenite**. Selenite crystals can be split into thin sheets like mica, but differing from mica in having no elasticity. A fine-grained translucent variety of gypsum is called alabaster. Satin spar is a variety composed of fine parallel fibres.

Gypsum in commercial quantities is always found in sedimentary rock formations, such as shale and limestone, and often associated with rock salt in such a manner as to suggest that both have been deposited by the evaporation of bodies of sea water. This could have happened by the separation of lagoons or bays from the rest of the ocean in such a way that in a dry climate the water evaporated faster than it was renewed. The occurrence of very great thicknesses of gypsum and salt can be explained by the flow of sea water through very narrow openings into such lagoons or bays to take the place of the water as it evaporated. Such nearly closed-off portions of the ocean can be now seen on the earth. There are other suggested explanations of the occurrence of layers of gypsum.

Anhydrite is sulphate of lime without the water that is part of the composition of gypsum. It is often found with gypsum. In Ontario it has been passed through in deep borings, but has not been found in any quantity in the gypsum mines. It is much harder than gypsum. Owing to the absence of water in its composition, it cannot be used instead of gypsum, but the occurrence of large quantities in some countries has stimulated research into possible uses. It can be converted into gypsum by grinding it very fine with water, but the process can hardly be commercially successful, so long as large supplies of gypsum are available. Much of the material formerly reported as gypsum has proved on closer examination to be anhydrite. In the gypsum formations, the anhydrite is

found below the gypsum. There may be an intermediate zones where the two minerals are mixed.

Uses. Gypsum is used as a fertilizer for land, and so is often called **land plaster. Raw** or uncalcined gypsum is used principally to mix with Portland cement as a "retarder" that is, to lengthen the timt of setting. It is added in the proportion of 2% to the cement clinker as it comes from tht roaster. Finely ground gypsum is sometimes mixed with barnyard manure in which it helps to retain the ammonia. Used by itself it has been found advantageous to crops of clover, beans and peas. It has found some uses as a flux in smelting lead and nickel ores, for filtering some kinds of oils, for phonograph records, for buttons, for blackboard crayons, as a base for paints, and to dilute certain insect poisons including Paris green, as a filler for paper and cotton, and as a body for asbestos packing and gaskets.

For its principal use as **plaster of Paris** or **stucco,** gypsum is **calcined,** that is, carefully heated until three quarters of its water is driven off. The resulting plaster of Paris is used as a finish over lime-sand plaster and in other places as "hardwall," "hard finish," and "flooring plaster," and in the manufacture of wall-boards, tile, and blocks for interior construction. Smaller uses are for interior wall decorations, moulds and patterns, casts of art objects, surgical and dental casts, safe construction, match heads, as a base for cold water tints, and to some extent in oil paints.

Gypsum blocks are made by casting plaster of Paris into the desired shape and size after mixing with water and shavings or excelsior. The blocks are then air-dried or dried by steam heat. They are used for partitions, firewalls, furring of walls and for heat insulation. They possess the advantages of lightness and fire resistance. In addition they can be sawn, bored, and in other ways shaped and worked. Their use as a construction material is increasing fast.

Gypsum board or **plaster board** is made in a similar way, using plaster of Paris mixed with sawdust, wood fibre or other material such as corn starch or dextrin to increase the toughness and lightness. It is sold under the name **gyproc** wall board.

For **wall plaster** the plaster of Paris is mixed with various materials (retarders) to increase the time of **setting.**

Insulex is made by mixing aluminum sulphate and finely ground limestone with plaster of Paris. When this is mixed with about half its bulk of water it swells to four or five times its original bulk, and sets in 20 or 30 minutes to a finely porous mass of very high heat-insulating power. The swelling is caused by the liberation of carbon dioxide from the limestone by the action on it of aluminum sulphate.

GYPSUM IN QUEBEC

Magdalen Islands

The only known deposits of gypsum in the province of Quebec are those of the Magdalen Islands, which are in the Gulf of St. Lawrence about 150 miles southeast of Gaspé. These islands are made up largely of

masses of diabase and other basic rocks that form rather conspicuous conical hills. The gypsum beds are associated with beds of limestone and form part of the Lower Carboniferous. They are similar in character to those of Nova Scotia. Of the ten islands forming the Magdalen group, Grindstone, Alright, Amherst, and Entry have the most important gypsum deposits.

The deposit on **Grindstone Island** has an area of 5.20 square miles, and as it forms high cliffs, the facilities for quarrying are good. There are many varieties of color and texture, and in places the gypsum is white and fine-grained. The cliffs, formed of marl, limestone, and gypsum, can be seen on the sea coast a short distance north of Cape Mule. From the shore the deposits can be traced by outcrops and depressions. to Etang du Nord where there is a prominent ridge of gypsum, and not far away a pond with gypsum cliffs 40 to 60 feet high.

On **Entry Island**, the gypsum is found on the south coast near the lighthouse. As exposed on the coast it is seen to be overlaid by beds of marl containing blocks of limestone and gypsum. The gypsum is white to dark gray, and mostly of a granular texture, but fibrous gypsum occurs, some of it pure white in color.

On **Amherst Island**, the gypsum can be seen on the coast at Pleasant Bay east of Demoiselle Hill. It has a total area of 720 acres. The deposit can be traced inland by depressions in some of which the gypsum can be seen. It is a white compact variety with occasional red streaks. There is a second area about 400 acres in extent in the northwest part of this island. It can be seen along the coast between Southwest

Cape and West Point. The overlying marl carries fibrous gypsum.

On **Alright Island** near Cape Alright the gypsum is to be seen in high cliffs of diabase on which the gypsum lies. This deposit extends across the island to Little Bay. Outcrops can be seen on the higher ground. Very pure white gypsum is found on lot 100.

There is good safe harborage for vessels of small draft. The population of the island numbered about 7000 in 1913. These gypsum deposits may be looked upon as important reserves to meet the growing demand for this material.

Reference: Geological Survey of Canada, New Series, Vol. X, 79S.

PETROLEUM AND NATURAL GAS

As these two important materials are so constantly associated in nature, they are described together. They are found in pools or reservoirs in sandstones and other porous rocks, the pores, joints and fissures of which are filled with the oil and gas. The origin of the materials is not known. There are two main theories, (1) the **organic**, which supposes the oil and gas to have been formed by slow alteration of accumulations of animal and vegetable remains, particularly diatoms, (2) the **inorganic**, according to which oil and gas have been formed by the action of subterranean hot water on carbides supposed to exist in the hot depths beneath the rocks. Most geologists favor the first theory.

While small quantities of oil and gas may be found under all sorts of conditions, for the accumulation of

the materials in commercial quantities, the following conditions must be fulfilled:

(1) A reservoir, consisting of a porous rock such as sandstone or dolomite.

(2) A capping of impervious rock such as shale or a tight limestone, to prevent the escape of the accumulated oil and gas.

(3) A geological structure to provide for the accumulation of the material, such as an anticline, especially where a cross folding has caused a dome-shape in the fold. There are a number of other geological structures that fulfil this condition, but all lead to the same result, the accumulation of the oil and gas by an upward flow into the pores, joints and crevices of rock that is capped by an impervious layer, and from which the material cannot escape upward because of the shape of the rock. Where water is absent, gravity may have caused the oil to settle into synclinal and other basins.

Experience shows that where these conditions are not fulfilled, gas and oil in commercial quantities are not found. The discovery of small quantities has often led to expensive drilling in unpromising situations. Such operations should not be undertaken without the advice of a geologist expert in the subject.

Oil and gas have been found in rocks of all ages. Gas has been found even in hard pan above the consolidated rocks, usually in gravel overlain by hard clay. It has also been found in Potsdam sandstone, the oldest of the Paleozoic formations, resting on igneous Precambrian rocks.

Natural gas consists largely of methane or marsh gas, a compound of hydrogen and carbon, with smaller quantities of heavier hydrocarbons (compounds of hydrogen and carbon) that can be condensed into a very volatile gasoline. Natural gas also contains small quantities of carbon dioxide, oxygen, nitrogen, hydrogen, and sometimes helium.

Natural gas is always present in an oil pool. If the top of the pool is drilled into, the well produces gas at first. If the pool is tapped lower down, the pressure of the gas drives the oil to the surface, and an oil well results. Occasionally a reservoir contains gas without any oil.

Petroleum is a mixture of hydrocarbons, some of which are of low boiling point and when separated from the rest constitute gasolene; others of higher boiling point make kerosene or "coal" oil; other parts are made into lubricating oils, vaseline, grease, paraffin wax and other products. Petroleum contains more or less sulphur, partly as sulphur itself dissolved in the oil and partly as compounds, including the malodorous gas, hydrogen sulphide. Sulphur and its compounds must be removed in the process of refining.

The Paleozoic rocks may be looked upon as the actual and possible sources of petroleum and natural gas in Quebec. From the oldest to the youngest, these rocks belong to four periods, Cambrian, Ordovician, Silurian, and Devonian.

In the sketch of the Geology of the province, the extent and distribution of these rocks are indicated. (See p. 20). Petroleum has been found in Gaspé, but not in profitable quantities. Wells bored in the coun-

ties near Three Rivers have yielded considerable flows of gas, but the supply was soon exhausted, as it came from superficial reservoirs. Gas in small quantities has been struck in a number of other places.

A great deal of the country that might be otherwise favorable for oil and gas is too much broken up by faults and intrusions of igneous rocks to prevent the escape of accumulations of oil and gas. In other places the favorable formations are without the cover of shale or other impervious layers, or there is an absence of anticlinal folds or of the dome structure, considered to be favorable features.

On the other hand, it must be acknowledged that a great deal remains to be done in respect of exploring and drilling. The later experience in the oil ond gas fields of Ontario has somewhat modified opinions regarding the conditions necessary for oil and gas accumulations.

In the following detailed descriptions, the counties and other areas are arranged in alphabetical order. Only those counties, etc., are included that have within their bounds geological formations and other conditions favorable to the occurrence of oil and gas.

BAGOT COUNTY

Bagot county is one of the "Eastern Townships" counties. Wells 100 feet or less in depth have given small showings of gas. In the western part of the county, Trenton limestone, which has been productive of oil and gas in Ohio and Ontario, has the necessary impervious cover, but the chances for large accumulations of oil and gas have perhaps been made small by

two faults that cross the county. It should not be forgotten, however, that faulting has sometimes resulted in sealing the edge of tilted porous beds in such a way as to prevent the escape of oil and gas.

BELLECHASSE COUNTY

This county is on the south side of the St. Lawrence River, a little below Quebec city. The county is crossed by belts of Cambrian and Silurian beds, in which there may be some chances of small oil and gas accumulations.

BERTHIER COUNTY

This county is on the north side of the St. Lawrence between Montreal and Quebec. It is crossed by a band of Ordovician formations, including Trenton limestone. Shallow borings near the villages of St. Justin and St. Barthelemi, made some years ago, gave small showings of gas.

CHAMBLY COUNTY

Chambly county is on the south side of the St. Lawrence opposite the island of Montreal. Trenton limestone covered by shales, etc., is present throughout the county, and as this rock has been productive in Ontario, Ohio, and Indiana, there may be a chance of finding oil and gas in this county. On the other hand, many wells bored in the same formations on the island of Montreal have yielded no important quantity of either.

CHAMPLAIN COUNTY

Champlain county is north of Three Rivers. It is crossed by a band of Ordovician formations including

Trenton limestone. Wells drilled to shallow depths have produced enough gas to supply individual houses for a time. Gas from a well in Champlain township proved to be a surface accumulation in a bed of gravel covered by clay.

DRUMMOND COUNTY

This county is in the "Eastern Townships," adjoining Bagot county on the northeast. The county is underlain by Ordovician beds that form an anticline striking northeast-southwest across the centre of the county. The Trenton limestone, which would be the most favorable for gas, is covered by shale over only a small part of its breadth. Another unfavorable condition is a fault along the northwest edge of the anticline. (But see Bagot County p. 304).

GASPE COUNTY

This is the only county in the province that has produced oil in commercial quantities. It lies at the end of the Gaspé peninsula, where the rocks are largely of Devonian age. Seepages of oil have long been known along the south shore of Gaspé Bay, along the York River, the St. John River, and in other places. Numerous wells have been bored along an area from Seal Cove on the south side of Gaspé Bay to Falls Brook, a branch of the York River, a distance of 33 miles. The greatest depth reached was 3,700 feet. There are a number of anticlines in the area, but there are also several faults. The extensive faulting is looked upon as unfavorable to the survival of large pools of oil. Other unfavorable circumstances are the very steep

dip of the rocks in many places, their shattered condition, and the rather numerous igneous intrusions. On the other hand, there is a large extent of drift-covered territory still to be explored. The production of the wells has been quite small, the best well having produced only 2000 barrels in all.

HOCHELAGA COUNTY

This county includes the city of Montreal and surroundings. The surface rocks consist mostly of Trenton limestone, an Ordovician formation that has been productive of gas in Ontario. The limestone has been intruded by masses of igneous rocks in Mount Royal and vicinity. Many wells have been drilled for water to depths from 300 to 2000 feet, entirely in sedimentary rocks, but gas has not been struck in important quantities. The conditions are unfavorable for large accumulations of gas.

JACQUES CARTIER COUNTY

The geological conditions are very similiar to those in the adjoining Hochelaga county, and are therefore not favorable to the accumulation of large quantities of oil or gas. Small quantities of gas, suitable for supplying single residences, may be found.

LAPRAIRIE COUNTY

This county is on the south side of the St. Lawrence River at Lake St. Louis. The conditions for oil and gas are partly favorable, as there is a great depth of Trenton and other sedimentary formations that carry oil and gas, and these are partly capped by shale. The

unfavorable condition is that the Trenton formation is uncapped in a belt crossing the whole county.

LOTBINIERE COUNTY

This county lies south of the St. Lawrence River between Quebec and Three Rivers. That part of the St. Lawrence valley has been considered favorable for the occurrence of oil and gas in important quantities. The sedimentary formations include Cambrian, Ordovician and Silurian beds in anticlinal and synclinal folds. In some places the Trenton beds that have been productive in Ohio and Ontario have an impervious capping. So far, however, no important results have been obtained by drilling operations.

MASKINONGE COUNTY

Maskinonge is one of the tier of counties along the north shore of the St. Lawrence river. It borders Lake St. Peter. It is mostly underlain by Precambrian rocks that are unfavorable to large accumulations of oil or gas, but the southeastern part of the county is crossed by Trenton and other Ordovician formations. This belt is 10 or 12 miles wide. Gas has been found in small quantities in wells drilled near Louiseville, Yamachiche, St. Justin, and St. Barthelemi; and it was assumed that the flow would be sufficient to supply Three Rivers and other places. The supply was, however, exhausted in a few months. (See **St. Maurice County,** p. 311).

NICOLET COUNTY

Nicolet county lies on the south side of the St. Lawrence River opposite Three Rivers. The geological for-

mations are of Cambrian and Ordovician age. The county is crossed in a north-easterly direction by the great Champlain-St. Lawrence fault, and a second fault occurs east of St. Leonard Junction. These disruptions of the rocks are considered unfavorable to the persistence of large accumulations of oil and gas, but in some exceptional cases the way of escape along the fault has been sealed by an impervious rock that has taken its place against the broken edge of the porous rock that carried the oil or gas.

In 1885 gas was struck at 1115 feet in a well bored at St. Gregoire. This well was estimated to yield 250,000 cubic feet a day, but the quantity proved to be small. Other wells bored in the vicinity yielded no important flows.

PORTNEUF COUNTY

This county is on the north shore of the St. Lawrence River west of the city of Quebec. It is mostly underlain by Precambrian rocks unfavorable to accumulations of oil or gas, but the band of sedimentary rocks of later age that parallels the St. Lawrence River crosses the greater part of this county not far from the river. Small quantities of gas have been struck in shallow wells drilled into these Ordovician beds. Shale impregnated with oil has been found in low, narrow, anticlinal ridges in the southern part of the county, but it is not thought that important pools will be found, as the anticlines are narrow and sharp. The anticlinal ridges near Pointe aux Trembles, although consisting of limestone covered with shale, are thought

to be too low and narrow to carry much oil. The greater part of these rocks forms a syncline.

RICHELIEU COUNTY

This county is on the south side of the St. Lawrence River opposite Joliette. The underlying rocks are limestones capped by shales. The structure in parts of the county has been considered favorable for gas. A well drilled about twenty years ago to a depth of 2950 feet did not strike any gas.

RIMOUSKI COUNTY

Rimouski county is on the south side of the St. Lawrence River below the city of Quebec. The southeast half of the county is underlain by rocks of Devonian and Silurian age, but in such a broken and highly tilted condition that they are unlikely to have retained large bodies of oil or gas.

ROUVILLE COUNTY

Rouville county is east of Montreal, the county of Chambly separating it from the St. Lawrence River. The geological conditions are in part favorable for the occurrence of oil and gas, as the Trenton limestone, productive in Ontario and Ohio, is under cover by shale, etc., throughout the greater part of the county. But the Champlain-St. Lawrence fault crosses the county, the Trenton limestone is not covered east of this fault, and four large intrusions of ingneous rocks further decrease the chances for important accumulations of oil or gas. There is, however, some chance that small gas wells may be brought in. It is

reported that showings of oil were found in 1908 at St. Paul d'Abbotshood.

ST. HYACINTHE COUNTY

This county is immediately north of Rouville county. It is east of the county of Vercheres, which separates it from the St. Lawrence River just below the island of Montreal. The geological conditions are much like those of Rouville county, but the Trenton limestone is completely covered. In 1910 a well was drilled at St. Barnabé and small amounts of gas are reported to have been struck. In the same year a well was drilled six miles northeast of the town of St. Hyacinthe on the farm of Joseph Fontaine. The well was put down 1880 feet, and a show of gas appeared at 1860 feet. The Trenton limestone was not reached. Recent experience in Ontario would favor the expectation of better results in that formation, supposed to be about 200 feet below the bottom of the St. Hyacinth well.

ST. JOHNS COUNTY

It is considered that the chances are very small for oil and gas in this county, which is west of the Richelieu River at the international boundary. The rocks that carry oil and gas are not under cover, and a fault runs north and south through the county.

ST-MAURICE COUNTY

St. Maurice county is on the north side of the St. Lawrence River, which it borders in the vicinity of the town of Three Rivers. The greater part of the county is underlain by Precambrian rocks, but, about

12 miles from the St. Lawrence, there is a band of Ordovician formations including Trenton limestone. This band crosses the county in a direction nearly parallel to that of the river. In 1883, a well drilled near the village of St. Maurice struck a strong flow of gas at a depth of about 70 feet. Another well was sunk to a depth of 1115 feet and gas was struck at various depths, the deepest yield being at 820 feet. In 1906-7 a number of holes were bored in this and the adjoining county of Maskinonge, and considerable quantities of gas were obtained, but the supply failed after a few months, as was predicted by geologists when it became known that the gas came from such small depths. (See **Maskinonge County,** p.308).

TEMISCOUATA COUNTY

This county is on the south side of the St. Lawrence River below Quebec city. It is underlain by sedimentary rocks of Cambrian, Ordovician, and Silurian age. While the rocks are of favorable age, the structure is not particularly favorable. There is, however, some chance for the occurrence of oil or gas pools.

VERCHERES COUNTY

This county borders the south side of the St. Lawrence River below Montreal. It is considered to be rather favorable for oil and gas occurrences, because parts of the county are underlain by shale covering limestone. About 20 years ago two wells were drilled to 2,450 and 2,300 feet. It is reported that small quantities of gas were encountered.

YAMASKA COUNTY

This county forms the south shore of the St. Lawrence River at Lake St. Peter. It is underlain by Ordovician and Silurian shale and sandstone covering Trenton limestone. There may be a low anticline about the middle of the county. It has been suggested that a well somewhere on a north-south line midway between St. Elphége and St. Zéphirin might be worth while.

Reference: Petroleum and Natural Gas Resources of Canada, by F. G. Clapp, Mines Branch, Ottawa, publications Nos. 229 and 291.

HELIUM

Helium is a gas present to a very small extent in the atmosphere, and in larger proportions in some natural gas. It is a product of the slow disintegration of radioactive elements such as radium, uranium, and thorium. These elements are present in the crust of the earth in sufficient quantity to account for the amount of helium in the natural gases. The properties of helium make it an ideal gas for filling ballons and dirigible airships. Hydrogen is lighter and so has a greater lifting power, but its combustibility makes it very dangerous. While helium is twice as heavy as hydrogen, it is not combustible. Its lifting power in air is 88% of that of hydrogen. Of late years it has been used for filling the dirigible airships, such as the **Bremen** that lately made the voyage from Germany to the United States and back. As helium is much less soluble than nitrogen in the liquids of the human body it has been suggested that a mixture of helium and oxygen might be used instead of air for supplying

deep divers when at their work. As is well known, the diver when ascending must come up in short stages with long rests, so as to allow the dissolved nitrogen to diffuse out of his body. A quick ascent would cause serious swelling or even bursting of the tissues by nitrogen coming out of the blood and other liquids as the pressure lessened. Other proposed uses of helium depend on its superior conductivity for heat.

An investigation of the natural gas fields of Canada has shown the presence of helium in the gas from several fields in quantities that are considered commercial. The richest gas in the East is that of Caledon township, Peel county, Ontario. The helium in the gas from three wells in this field averages 8 cubic feet per 1,000 of gas. The gas in the Woodhouse, Norfolk county field averages 3.8 cubic feet of helium per 1,000 of gas. While the gas in the other fields shows a substantial amount of helihm, it could not be commercially extracted, either because the flow of gas is too small or because the helium content is too low.

The extremely low liquefying temperature of helium (—269° Centigrade) makes its separation from the other gases theoretically very simple. The gases that are mixed with helium are liquefied at a very low temperature, and the still gaseous helium is pumped off. The natural gas, as it evaporates, goes into the mains for use as a combustible. The machinery by which this separation is effected is much like that for making liquid oxygen.

Helium has not been found in quantity in the province of Quebec.

Reference: Helium in Canada, by H. T. Elworthy, Mines Branch, Ottawa, publication No. 679.

COAL

The geology of Quebec is not favorable for the occurrence of coal. The youngest consolidated rocks in the province, are those of Devonian age. Nearly all the coal produced in the world comes from rocks younger than the Devonian. While it is true that some coal has been produced from Devonian rocks in Russia, there is so far no indication that this exceptional experience will be repeated in Quebec.

CLAY

Clay is a superficial deposit of very fine-grained material composed more or less of the mineral **Kaolin** or **Kaolinite,** and having the property of making a sticky plastic mass with water. The essential part of clay deposits is a hydrated silicate of aluminum called kaolin when in its pure state. The properties of clay depend on the other substances mixed with the kaolin and also on the physical properties of the kaolin itself. Pure kaolin stands a very high temperature without softening, but if it is mixed with oxides of iron and certain other substances the softening temperature is lowered. The pure mineral burns white, and this is one property that gives it value for making porcelain and other white ware. Oxides of iron give a red or yellow color to the ware.

Kaolin is a secondary mineral, resulting from the alteration of minerals high in aluminum, such as feldspars, micas, and hornblendes. The commonest minerals that change into kaolin are the feldspars, which by the action of water and carbonic acid lose potash,

soda, and lime, and at the same time combine with water. It follows that granite, syenite, diorite, diabase, and gabbro, of all of which feldspars are essential constituents, are the usual rocks that form deposits of kaolin by weathering. Of these rocks, granite and syenite are the commonest origins of clay. When the kaolin remains in the position where it is formed, more or less mixed with quartz and other minerals that have not suffered change, it is called a **residual clay deposit.** When it has been washed into a hollow, such as a lake basin, it is called a **sedimentary clay deposit.** Deposits that have been mixed with gravel and boulders by glacial action are called **boulder clay.** Boulder clay may have resulted from the transportation of clay beds formed before the glacial period, the ice having mixed clay with stones as it pushed the mass along; or the clay may have been formed from the very fine material produced by the grinding action of the glaciers. Lake Louise is being slowly filled up with white clay carried into its basin by the streams coming from Victoria glacier.

As Quebec is a glaciated country, most of its preglacial clay deposits, doubtless very widespread and extensive, have been transported by the ice sheet and converted into boulder clay. Some of the clay was washed out and settled in hollows such as lake bottoms when the ice melted at the close of the last glacial period. These clay beds show stratification, not seen in the boulder clay.

Glacial clay is widespread in Quebec. It forms the basis of the soil in most of the best farming areas. A great deal of it was gathered by the ice in the far

north and spread out farther south where the climate is now mild enough for farming.

Clay suitable for making bricks and tiles can be found in a great many parts of the province, but certain beds are favored either because of the superior quality of the clay or because of transportation facilities or nearby market. As shale is hardened clay. when its quality is right, it can be ground up with water and made into bricks, tiles, etc. The total value of clay products made in Quebec in 1928, exclusive of Portland cement, was $3,298,241.

Crude china clay sells at $6 to $9 a ton f.o.b. at some point at or near the manufactory. Washed and refined china clay is priced at $8.75 to $15 a ton. Clay imported across the Atlantic sells at $14 to $24 a ton, the high price being due to the reputation, careful refining, and uniform quality of the clay. A good deal of china clay is used in the manufacture of paper. Some of the large Canadian paper mills are said to be using 2,000 to 3,000 tons a year.

Kaolin or China clay has been found in economic quantities in only one place in the Province. The deposits of Rémi d'Amherst occur in Grenville quartzite, the main one on lots 2 to 10, range VI south, in Amherst township, and a smaller one on lot 8, range IV. The quartzite carrying the kaolin forms the western slope of a ridge lying between ridges of granite and gneiss. The quartzite has been so shattered that it is in a friable condition almost like sand. The kaolin fills the spaces between the quartz grains in a zone up to 100 feet or more in width, and at least 7000 feet long. Diamond drilling has shown that the kaolin con-

tinues to at least 150 feet in depth. A sample taken across 133 feet carried 11% of kaolin. The washed kaolin "has greater plasticity and higher shrinkage than most of the standard brands of washed kaolin or china clay." It is suitable for making kaolin fire-brick, and for similar purposes. The purer parts of the deposit are suitable for use in the manufacture of paper and porcelain ware. Outside the deposits of kaolin the quartzite wall rocks carry a sufficient amount of kaolin to make the material suitable for the maufacture of silica bricks.

The Canadian China Clay Co., Ltd., operated these deposits for a number of years and produced material suitable for use as paper clay and the manufacture of porcelain, silica bricks and fire bricks. Analysis of the best quality of kaolin showed 1.06% of iron oxide, the material that may give an objectionable color to porcelain manufactures if present in too great proportion. The quantity mentioned is stated to be below that in the best Cornish clay as imported in Canada. Some of the clay contains a little graphite.

The greater part of the kaolin produced by the Canadian China Clay Co. was sold to the paper companies. The company ceased operations several years ago.

References: Geological Survey of Canada, New Series, Vol. VII, p. 101A.

Bulletins of the Department of Mines of Quebec.

CHAPTER XVI

NON-METALLIC MINERALS (Cont'd)

LIMESTONES, ETC.

Limestone is essentially carbonate of lime, (calcium carbonate) but this is always mixed with more or less of other substances. When the rock contains more than a small percentage of carbonate of magnesia, (magnesium carbonate) it is called **magnesian** or **dolomitic limestone**, and when the proportion of the two carbonates is about even, (theoretically 54.35% carbonate of lime and 45.65% carbonate of magnesia) the rock is **dolomite**. It is harder than calcite limestone, and quarrymen often call it **hard limestone**. Carbonate of lime as a distinct mineral is called **calcite**. Its color is white, so that the various shades of color seen in limestones are due to the impurities.

Limestone is a sedimentary rock formed of the shells of minute and sometimes larger shellfish. The animals make their shells by extracting calcium carbonate from the water. Part of this material is precipitated directly from the water. The sediment thus formed in past ages has become the solid rock known as limestone. From its method of formation, it can be seen that some beds would have clay and even very fine sand mixed with the calcium carbonate. Thus have

been formed **argillaceous (clayey) limestones** and **siliceous limestones.**

It is seen that limestones vary a good deal in color, hardness, and composition. It is necessary to select a limestone of the right composition for any one of the many uses to which it is put. This selection can be made only by chemical analysis. But a certain bed or layer is apt to be fairly uniform in composition.

The ordinary sedimentary limestone often shows little or no grain, but it is sometimes semi-crystalline. Older limestones have undergone a change due to heat from masses of igneous rocks, and in part to heat generated by pressure. These agencies have caused crystallization. The crystals may be small or larger. At the same time the impurities that gave the gray, yellow, buff, or bluish color to the original stone, have more or less completely disappeared, and the limestone may have become white. This altered rock is called **crystalline limestone.** When the grain, color, and other properties are right, the stone is useful as **marble.** Crystalline limestone often contains inclusions of granite and gneiss, grains and stringers of quartz, tourmaline, pyrite, magnetite, feldspar, pyroxene, flakes of mica and graphite, and other impurities that make it useless for many industrial purposes.

Calcite is sometimes deposited in veins of such size and purity as to be of commercial importance.

USES

Building Stone. The unaltered beds of limestone make good building stone, easily quarried and worked, and often of pleasing appearance.

To be suitable for building stone, limestone must be free from materials such as pyrite and siderite that cause a rusty stain or weathering. It must also be free from shaley partings that impair the strength of the stone. The thickness of sound layers should be great enough to give suitable blocks of stone. The thinner layers are sometimes used for foundations, and for crushed stone for concrete and railway ballast.

The use of limestone as building stone has been much affected by the growing use of concrete for many construction purposes, but it is probable that there will always be a demand for limestone of a pleasing color and good general appearance.

Marble. The crystalline limestones of Canada are most abundant in Ontario and Quebec. They are geologically very ancient, belonging to a rock series called **Grenville**, from Grenville in Quebec, where they were first recognized and described. In some places they are of marble quality, and there seems to be no good reason why the Canadian demand for marble should not be supplied from these sources. Some of this marble is pretty pure carbonate of lime, and is therefore softer than the dolomite marble found in other places.

Lithographic Stone. For making lithographs a limestone is required of very fine grain, and free from cracks and grains of hard minerals. There must also be no crystallized carbonate of lime to mar the uniformity of the texture. So far, no stone has been found in Canada from which large enough slabs can be cut of the required quality.

Portland Cement. For making Portland cement, the materials required are clay and limestone. In

Canadian cement works marl is used largely instead of limestone. Marl is a carbonate of lime deposit found in the bottoms of shallow lakes or in places where such lakes have been drained by some natural change in levels. Limestone not suitable for some purposes because of the large proportion of shale in it may be satisfactory for making cement, as the shale is often of the same composition as clay.

Sulphite Pulp Process. Most of the pulp and paper made from wood is manufactured by the sulphite process. This involves heating the prepared wood in sulphite liquor, made by treating limestone and water with sulphur dioxide gas made by burning sulphur or iron pyrites. The resulting liquor is a solution of bisulphite of lime. The limestones preferred for this purpose are those as high as possible in magnesia so that the liquor contains also bisulphite of magnesia. The limestone must be free from impurities that would be carried into the paper and spot it. This rules out some crystalline limestones that contain flakes of graphite and black mica. The high magnesia limestone is preferred because of the sparing solubility of sulphate of lime, formed in some quantity during the process. It may crystallize in the paper as gypsum and spoil the texture of the paper. Sulphate of magnesia, being very soluble, easily washes out.

Limestone as a Flux. In smelting operations limestone is often used as a flux, that is, to combine with silica and other materials in the ore so as to make a slag that will flow easily. Large quantities are used for this purpose in the manufacture of pig iron. If copper and nickel ores are siliceous, lime is used in

smelting them. In the manufacture of pig iron, limestone high in magnesia is preferred, as the magnesia tends to carry off the sulphur. For the manufacture of pig iron, the limestone must be very low in phosphorus and sulphur.

Glass Manufacture. Common glass is a mixture of silicates including silicate of lime and silicate of soda. The lime silicate requires limestone. Carbonate of soda and glass sand supply the other materials. For glass-making a limestone low in magnesia is best, as magnesia tends to raise the melting point of the glass.

Lime. Lime is calcium oxide, made by strongly heating limestone so as to drive off carbon dioxide. This gas is sometimes collected, liquefied by compressing it in steel cylinders, and used for various purposes including the making of fizzing drinks. If the limestone contains carbonate of magnesia, the resulting lime is a mixture of calcium oxide and magnesium oxide (magnesia). A "fat" lime is one having little magnesia in it. In slaking or hydrating lime, the calcium oxide combines with water, and this operation generates a good deal of heat. Magnesia combines very slowly with water and there is little generation of heat. Thus, in the process of slaking, a fat lime gives off more heat than a high-magnesia lime.

Lime has a large number of uses, including the making of mortar for laying bricks and stones, the manufacture of sand bricks, silica bricks, calcium carbide, acetate of lime, chloride of lime, calcium chloride, etc. It is used in the purification of beet sugar and for removing the sulphur from coal gas. An important use is for furnace linings for the basic steel process.

The lime removes phosphorus from the steel and thereby improves its quality.

For these various uses, the lime must be made from suitable limestones. High calcium limestones are preferred for most purposes, but other requirements must be fulfilled. For example, lime for making calcium carbide must be free from phosphorus.

Whiting, Stucco Dash, etc. Crystalline limestone of good quality has been ground and used as a substitute for **whiting** made of chalk, and for other purposes.

Well-crystallized calcite that breaks with good cleavage is used as **stucco-dash,** etc.

Iceland Spar is very perfect crystals of calcite used in making certain parts of optical instruments. For this purpose the requirements are very exacting, including perfect transparency, freedom from cracks and other flaws, and absence of any distinct color other than a pale yellow. Crystals satisfying the requirements have been found in very few places. The Iceland locality cannot supply the world's requirements, and other sources are eagerly sought by the optical instrument makers. Iceland spar of the best quality sells for $10 to $20 a pound.

The province is well provided with limestone in those parts underlain by Paleozoic rocks (See p. 17 and p. 20), which are in large quantity in the southwestern part of the province along the St. Lawrence and Ottawa rivers, and in smaller areas near Lake St. John and Lake Timiskaming. There is also a considerable development of Paleozoic limestones of good quality on the south side of the Gaspé peninsula. In addition to these limestone resources, there are the Precambrian

(See p. 17) crystalline limestones, many bands of which occur north of the Ottawa River and eastward as far as Champlain county or farther; but they are mostly too far from transportation to be important at present.

PALEOZOIC LIMESTONES

The Paleozoic limestones underlie most of the southwestern part of the province on both sides of the St. Lawrence River from the Ontario boundary to within a few miles of Lake St. Louis. South of Lake St. Louis there is a large block of limestone country reaching the international boundary, and extending eastward nearly to the Richelieu River. Another large block north of the St. Lawrence River includes the islands of Montreal, Bizard, Jésus, and parts of the counties of Two Mountains, Terrebonne, L'Assomption, and Montcalm. Paleozoic limestones form a narrow band stretching parallel to the St. Lawrence from Joliette to a point about 35 miles west of Quebec city. This limestone band touches the St. Lawrence river between Grondines and Deschambault and again at its eastern end at Neuville. The Canadian National railway follows it throughout the greater part of the length of the band, and the Canadian Pacific railway crosses it at several places. The limestone formations are found at intervals farther east along the north shore of the St. Lawrence. There are several outliers in the Lake St. John district.

From Two Mountains county a band of limestone extends westward along the north shore of the Ottawa River, and is continued by patches along the

river and on the islands as far west as Allumette Island in Pontiac County. In Vaudreuil county there is an area of limestone on the south side of the Ottawa filling the corner between the river and the Ontario boundary. In Terrebonne county there is a limestone outlier east of the Canadian Pacific railway line from Montreal to Mont Laurier, about 9 miles northwest of St. Jerome.

In the Eastern Townships there are limestone areas of considerable size in Missisquoi and Brome counties. One of these areas extends from the international boundary near Philipsburg northward towards Farnham. Another, continuous with the first along the international boundary, forms a branch stretching northeastward through Missisquoi and Brome counties. There is a small area around St. Dominique in Bagot county. Limestone forms both shores of Lake Memphremagog in its northern part. There is a small patch south of Stoke Centre, Richmond county, and a larger area following the Canadian Pacific railway line through part of Wolfe County. In addition to these areas there are in the Eastern Townships occasional bands of impure limestone of no value for industrial purposes.

HUNTINGDON COUNTY

Limestone underlies the western and a section of the eastern part of Huntingdon county, and it has been quarried at points from 2 to 3 miles west of Huntingdon. The stone approaches dolomite in composition. It is high in ''insoluble'' and in iron oxide.

BEAUHARNOIS COUNTY

The southwest half of this county is underlain by limestone. Quarries have been operated at Valleyfield, crushed stone being the chief product.

MONTREAL ISLAND, etc.

The islands of Montreal, Bizard, and Jésus are underlain by limestone. Building stone is quarried at Villeray and other points on the island of Montreal, and at St. Francois de Sales, Bélanger, and Cap St. Martin on Ile Jésus. Crushed stone is produced at St. Laurent and Villeray on the island of Montreal, and at Cap St. Martin on Ile Jésus. Lime and Portland cement are produced from limestone quarried on the island of Montreal.

LAPRAIRIE COUNTY

The whole of this iounty is underlain by limestone, and building stone has been quarried at Caughnawaga and 3 miles west of St. Johns.

NAPIERVILLE COUNTY

Limestone underlies the whole of Napierville county A quarry has been opened at Ste. Clothilde.

ST. JOHNS COUNTY

The western part of this county is underlain by limestone. A quarry has been operated 2½ miles west of St. Johns, and another north of Grande Ligne.

MISSISQUOI COUNTY

There are two north-south bands of limestone in Missisquoi county. They unite along the international boundary. The quarry of the Canada Carbide Com-

pany, Ltd., is at Morgan Corners. The limestone analyses 98.93% calcium carbonate This limestone is semi-crystalline and in grain and color is suitable for use as marble. Near Philipsburg decorative building stone is quarried extensively by the Wallace Sandstone Co.

BAGOT COUNTY

In the southwest part of Bagot county there is a small area of limestone near St. Dominique. The quarries there produce building stone, crushed stone, and lime.

WOLFE COUNTY

A band of Silurian limestone extends from the southern end of the county northward along the line of the Canadian Pacific railway. West of the line, at Lime Ridge, is the quarry of the Dominion Lime Company, Ltd. The stone is a pure, high-calcium limestone, suitable for lime, for the sulphite pulp process, and for other purposes requiring high-calcium limestone.

ARGENTEUIL COUNTY

The southern part of this county is underlain by limestone, and a quarry has been operated south of Lachute. The stone approaches dolomite in composition.

TERREBONNE COUNTY

The southern part of Terrebonne is underlain by limestone. A quarry half a mile south of St. Thérèse station has been operated in dolomitic limestone.

L'ASSOMPTION COUNTY

The greater part of this county is underlain by limestone, and stone has been quarried one mile west of St. Lin.

JOLIETTE COUNTY

The limestone band crosses the southern part of Joliette County, and there are important quarries in the county, near the town of Joliette. The limestone is pure and high-calcium. Building stone, crushed stone, and lime are produced.

BERTHIER COUNTY

As it crosses Berthier county, the limestone band is from 4 to 8 miles wide. There is a quarry at St. Cuthbert on the Canadian National railway.

CHAMPLAIN COUNTY

The limestone band crosses Champlain county between the Canadian National and Canadian Pacific railway lines. The Ordovician limestone quarried at St. Louis-de-France is a pure, high-calcium stone suitable for making lime and for other chemical purposes.

PORTNEUF COUNTY

In this county the limestone band touches the St. Lawrence, forming the shore line between Grondines and Deschambeault, and again at Neuville. There are extensive quarries in this area, particularly near St. Marc-des-Carrières. This is one of the principal centres for the production of building stone and lime.

QUEBEC COUNTY

Continuous for about 120 miles from L'Assomption to Portneuf county, the limestone band ends in the latter county, but is represented in Quebec county by a strip (outlier) extending from Lorette eastward

through Beauport to Montmorency Falls. The stone is in thin beds, easily quarried and crushed. There are quarries at Lorette and Beauport.

MONTMORENCY COUNTY

Limestone outliers occur at Chateau Richer and St. Joachim in this county. Crushed stone is produced at Chateau Richer.

CHARLEVOIX COUNTY

A limestone outlier occurs at Baie St. Paul in the valley of the Gouffre River. The stone is impure, but is occasionally quarried and burned for lime. A little is used as agricultural limestone.

SAGUENAY—LAKE ST. JOHN DISTRICT

Outliers of limestone occur at Ste. Anne across the river from Chicoutimi and for some distance northward. A belt of limestone from a few hundred yards to several miles wide skirts the southern and western shores of Lake St. John. The stone has been used locally in the pulp mills, but stone from a distance has taken its place. The local limestone is burned for lime at Ste. Anne de Chicoutimi. Quarries have been operated for crushed stone.

PRECAMBRIAN LIMESTONES

The crystalline limestone of the Grenville series occurs as bands with a northeast-southwest strike in the region north of the Ottawa River from Black River in Pontiac county eastward as far as Champlain county.

Crystalline limestone forms a band extending from southeast of Brome Lake in Brome county to a point near Lawrenceville in Shefford county. At South Stukely it has been quarried as marble. Lately the stone has been burned for lime. Crystalline limestone is also reported in some of the less accessible parts of the province. The bands of limestone vary in size from short strips a few feet in width to areas several miles across and many miles long. In composition the Grenville limestone varies from high calcium to dolomite and calcareous magnesite. It has as impurities inclusions of granite and gneiss, and grains of quartz, tourmaline, pyrite, magnetite, pyroxene, feldspar, mica, graphite, etc. In much of the limestone, these impurities are present in such quantities as to make it useless for industrial purposes, but as a good deal of it is dolomite, it should be looked upon as a possible source of that material for use in the sulphite pulp process. It has been noticed that the dolomite is more apt to be free from impurities than the high-calcium stone. Crystalline limestone is usually too soft and friable to use as crushed stone. When of the right quality it is marble.

Quarries have been operated at Portage du Fort, Pontiac county, at L'Annonciation, Labelle county, and at St. Thècle, Champlain county. A little of the Portage du Fort stone has been burned for lime. At St. Thècle the Marble Company of Canada takes out decorative stone. Many years ago a small quarry was opened in crystalline limestone near Grenville village, Argenteuil county, to supply stone for a sulphite pulp mill. It was abandoned when it was found that the

flakes of mica and graphite in the stone were carried into the pulp.

Reference: Preliminary Report on the Limestones of Quebec and Ontario, by M. F. Goudge, Mines Branch, Ottawa, Publication No. 682.

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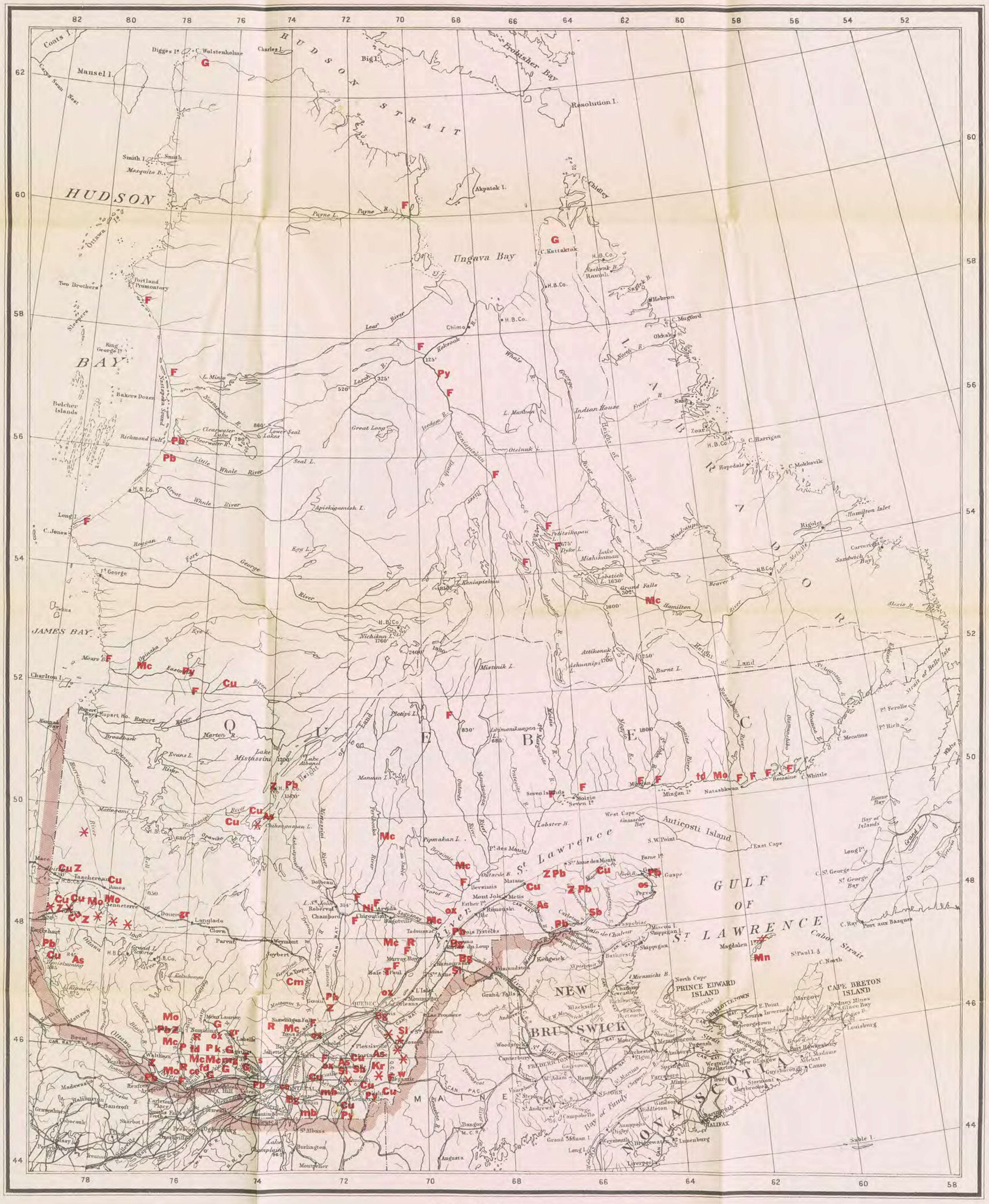
QUÉBEC, CANADA
SERVICE DES MINES

DEPARTMENT OF HIGHWAYS AND MINES
QUEBEC, CANADA
QUEBEC BUREAU OF MINES



LÉGENDE
LEGEND

Or	✳	Gold
Plomb	Pb	Lead
Zinc	Z	Zinc
Antimoine	Sb	Antimony
Tourbe	Bg	Peat
Schistes pétrol.	os	Oil shales
Apatite	P	Apatite
Amiante	As	Asbestos
Mica	Mc	Mica
Fer	F	Iron
Molybdène	Mo	Molybdenum
Manganèse	Mn	Manganese
Cuivre	Cu	Copper
Chrome	Kr	Chrome
Grenat	gr	Garnet
Gypse	#	Gypsum
Marbre	mb	Marble
Magnésite	mg	Magnesite
Graphite	G	Graphite
Ardoise	Sl	Slate
Pyrite fer	Py	Pyrite
Ciment	ce	Cement
Feldspath	fd	Feldspar
Oxyde fer hydr.	ox	Hyd. iron oxide
Min. radio-act.	R	Radioact. min.
Cérium	Cm	Cerium
Kaolin	k	China Clay
Silice	s	Silica
Tungstène	w	Tungsten
Titane	T	Titanium
Nickel	Ni	Nickel

CARTE MINÉRALE DE LA PROVINCE DE QUÉBEC CANADA

Echelle, 100 miles au pouce
Scale, 100 miles to one inch
0 50 100 200 300
Kilometres
0 100 200 300 400

1930

MINERAL MAP OF THE PROVINCE OF QUEBEC CANADA